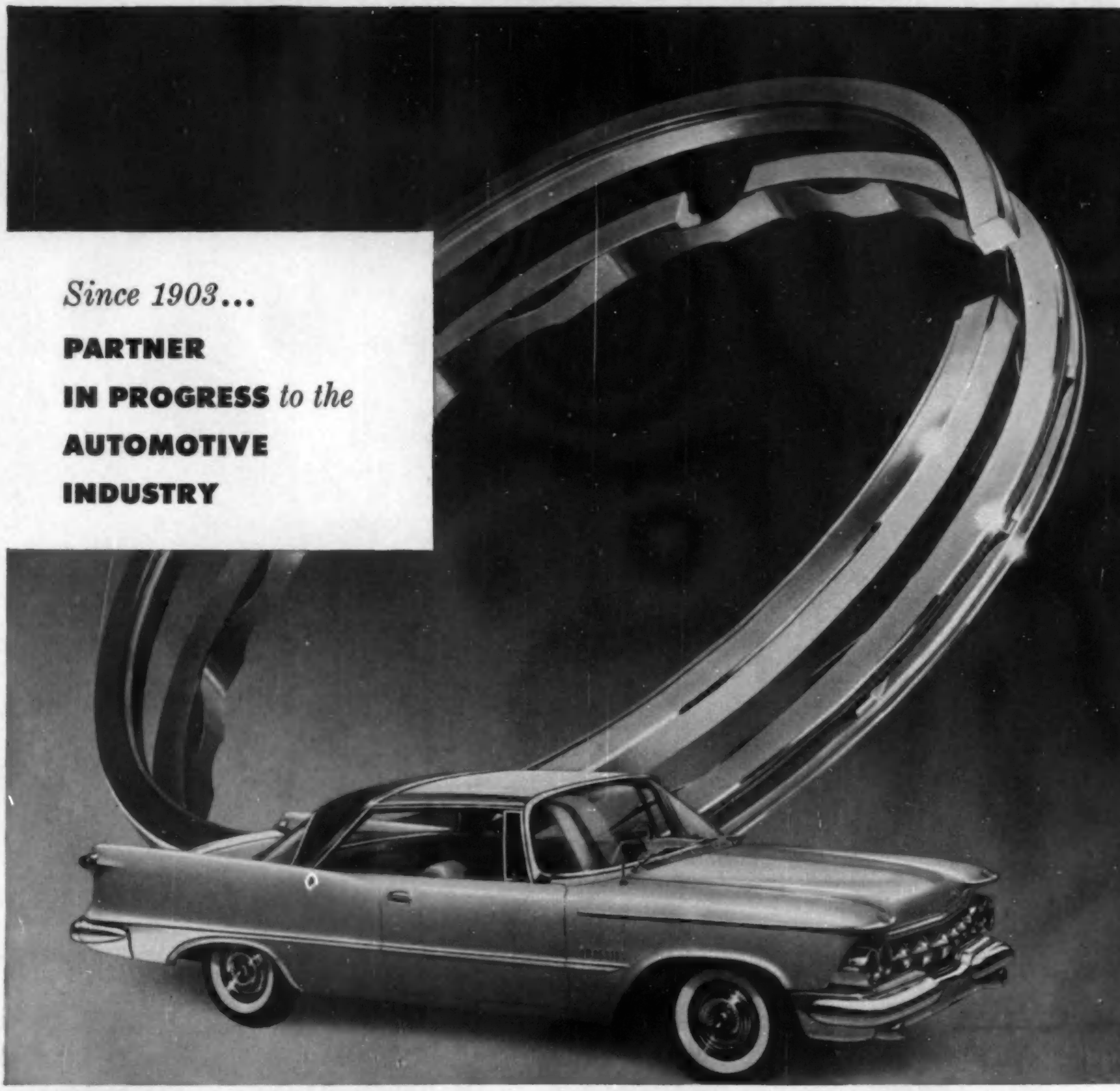
SAE Journal

NOVEMBER 1958

IN THIS ISSUE . . .

Published by The Society of Automotive Engineers



IMPERIAL—one of the outstanding motor cars using Perfect Circle piston rings for original equipment.

Behind the world-wide preference for Perfect Circle piston rings is a history of more than half a century of PC engineering leadership—and more. There's a history, too, of unceasing creative research...a constant search for the new and the better...matchless manufacturing skills...and scores of contributions to the forward march of the automotive industry, year after year. Whenever you have a problem concerning piston rings or related engine components, you are invited to call upon our engineering and research facilities. Perfect Circle Corporation, Hagerstown, Ind.; The Perfect Circle Co., Ltd., 888 Don Mills Road, Don Mills, Ontario, Canada.

PERFECT CIRCLE
PISTON RINGS

AUTO-PILOT

a new dimension in driving...

Auto-Pilot—a product of Perfect Circle research and engineering—prevents unintentional speeding in city, country and turnpike driving, yet keeps full engine power at your instant command. Lets you keep your eye on the road—and off the speedometer. Provides "robot throttle," permitting restful highway cruising with your foot off the accelerator pedal. Available now on the magnificent 1959 Chrysler and Imperial motor cars. Auto-Pilot is manufactured by the Speedostat Division of Perfect Circle Corporation.

SAE journal

Society of Automotive Engineers

EDITORIAL DEPARTMENT

editor, Norman G. Shidle
managing editor, Eleanor D. Allen
associate editor, David L. Staiger
technical editor, Otto W. Vathke
engineering editor, Frances L. Weeden
engineering editor, Walter G. Patton
production, Mary Grillon

OFFICERS OF SAE

president, William K. Creson
treasurer, B. B. Bachman
sec. & gen. mgr., John A. C. Warner

SAE PUBLICATION COMMITTEE

chairman, Leonard Raymond
E. F. Gibian
William Littlewood
C. A. Lindblom
W. F. Rockwell

Publication Office
10 McGovern Ave., Lancaster, Pa.

Society Headquarters
Editorial and Advertising Office
485 Lexington Ave., New York 17, N. Y.
Tel: OXford 7-3340; Teletype: NY1 228

Detroit Branch manager, G. J. Gaudaen
635 New Center Bldg., Detroit 2, Mich.
Tel: TRinity 1-1772; Teletype: DE 826

West Coast Branch manager, E. W. Rentz, Jr.
714 W. Olympic Blvd., Los Angeles 15, Cal.
Tel: RIchmond 9-6559

ADVERTISING OFFICES

advertising sales manager, Edward D. Boyer
485 Lexington Ave., New York 17, N. Y.

A. J. Underwood
635 New Center Bldg., Detroit 2, Mich.

W. W. Milne
7530 Sheridan Rd., Chicago 26, Ill.

Hamilton E. Finney
3537 Lee Rd., Shaker Hts., Cleveland 20, O.

Chris Dunkle & Assocs., Pacific Coast Reps.
740 S. Western Ave., Los Angeles 5, Calif.

420 Market St., San Francisco 11, Calif.

Contents • November 1958

To order papers on which articles are based, see p. 6.

Continued on page 2

Contents • November 1958 • Continued

More on page 1

To order papers on which articles are based, see p. 6.

Departments

READERSHIP RESEARCH

Briefs of SAE PAPERS

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Readers Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.

AIRCRAFT

Strength and Thermal Limitations of Materials for Airframe Components, J. C. EKVALL. Paper No. S109 presented Mar. 1958 (Southern Calif. Sec.) 11 p. Review of properties of presently available and advanced development alloys in following groups: magnesium, and titanium alloys, low alloy steels, corrosion resistant steels, and nickel, cobalt and mixed base alloys; strongest materials in each group are selected to make comparisons of strength of typical airframe components at various temperatures; material-efficiency curves.

FUELS & LUBRICANTS

Gulf's New Automotive Laboratory — Design for Versatility, E. W. JACOBSON, H. O. CREAZZI, C. W. BUTLER. Paper No. 72A presented Aug. 1958, 40 p. Automotive Engine Test laboratory at Harmarville, Pa., for evaluation of petroleum products, consists of fuel handling center and other testing facilities, inspection maintenance and overhaul facilities; CFR (Cooperative Fuel Research) Engine Wing and Central Test Wing with respect to test cell equipment, dynamometers, engine cooling and oil cooling system, instruments and controls; cold test area; gas and fire protection system.

New Facility for Fuel and Engine Lubricants Research, A.G. CATTANEO, R. A. COIT, A. R. ISITT. Paper No. 72E presented Aug. 1958, 16 p. Features of main FELD (Fuels and Engine Lubricants Dept.) building of Shell Co. at Emeryville, Calif., consisting of three chemical laboratories with adjacent constant temperature hot and cold rooms, engine test area, laboratory for combustion apparatus, fuel and lubricants storage and handling facility, etc; ventilation and heating; special safety features.

Diesel Fuels — Confusion Compounded — Why? G. K. BROWER, W. LENZI. Paper No. 74A presented Aug. 1958, 21 p. Development background of diesel fuel classifications and causes for confusion now existent; characteristics of fuels available; diesel fuel specifications as published by major consumers and engine builders; data concerning related fuel types; proposals for promulgation of commercially realistic fuel classification.

Economics of High Octane Gasolines, F. W. KAVANAGH, J. R. MacGREGOR, R. L. POHL, M. B. LAWLER. Paper No. 74B presented Aug. 1958, 33 p. Analysis of costs and value; economics is based on present practices regarding improved efficiencies of higher compression ratio cars and higher manufacturing costs of higher octane gasolines; it is believed that if compression ratio and octane number stay in proper relation to each other, consumer will benefit.

Chassis Dynamometer Facilities of Pure Oil Company Research Center, D. J. WANGELIN, F. T. FINNIGAN. Paper No. 72B presented Aug. 1958, 12 p. Chassis dynamometer and environmental test cell for full scale automotive engines; dynamometer supplements road testing program with tests run under controlled conditions; test cell provides means of operating en-

Continued on page 6

Readers' Information Service

Advertising Information Available

- **If you would like further engineering information on any of the products ADVERTISED in this November 1958 issue, CIRCLE THE APPROPRIATE PAGE NUMBERS in the list BELOW. Requests will be forwarded to the advertisers.**
- **Please fill in your NAME, COMPANY, AND ADDRESS on the BACK of this form.**

3	114	133	152	171	186 bottom
4	115	134	153	172	187
7	116	135	155	173	188 top left
8	117	136	156	174	188 top right
9	118	138	157	175	188 bottom
10	121	139	158	176	189
11	122	140	159	177	190
12	123	142	161	179	191
13	124	143	162	181	193
15	125	144	163	182	194
16	126	145	164	183	Inside front cover
17	127	146	165	184 top left	Inside back cover
19	128	147	166	184 top right	Outside back cover
21	129	148	167	184 bottom	
22	130	149	168	185	
24	131	150	169	186 top left	
113	132	151	170	186 top right	

- **COMPLETE PAPERS on which November SAE Journal articles are based are available in multilith form. Circle PAPER NUMBERS ON THE BACK OF THIS FORM of any papers you wish to buy.**

SAE JOURNAL, November, 1958, Vol. 66, No. 11. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $12 per year; foreign $14 per year; to members 50¢ per number, $5 per year. Entered as second class matter, Sept. 15, 1948, at the Post Office at Lancaster, Pa., under the act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of Feb. 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y. Second class postage paid at Lancaster, Pa. and additional office N. Y. C.

Briefs of SAE PAPERS

Continued from page 5

gines at controlled ambient temperatures of – 40 F and up under conditions of controlled humidity and temperature; design details of installations and refrigeration system.

Versatile Chassis Dynamometer, C. C. MOORE. Paper No. 72C presented Aug. 1958, 9 p. Features of modified 300-hp Midwest dynamometer incorporating electronic circuit, installed at laboratory of Union Oil Co. of Calif.; wind source is large multivane blower connected to constant speed, 3-phase, 60-hp motor; three function loadings of dynamometer to duplicate road performance are road friction, acceleration of mass, and wind resistance; how to set up controls for acceleration patterns; instrument panel board and accessories used.

GROUND VEHICLES

Chevrolet's New Engineering Laboratory, M. M. ROENSCH, N. E. FARLEY. Paper No. 72F presented Aug. 1958, 14 p. Engineering Center, located adjacent to GM Technical Center, houses product engineering requisites and laboratories; major areas in laboratory include physical testing; engine development and testing; transmission testing; electrical and instrumentation testing; engine, axle and transmission testing; chassis, dynamometer and vehicle dynamics; typical test projects.

Heavy Duty Air Suspensions for Trucks, Buses and Trailers, W. E. WHITE. Paper No. 73A presented Aug. 1958, 11 p. It is shown that riding comfort is improved by reducing suspension frequency and that properly designed air suspension can easily approach and maintain 100 cycle per min range empty or loaded, while conventionally sprung commercial vehicles vary from over 200 cycles empty to 100 loaded; method used by various manufacturers to dampen, to control sway, axle position and leveling; details of various makes.

What is to Come in Heavy Duty Transmissions — Mechancial - Automatic, L. FLYNN. Paper No. 73B presented Aug. 1958, 7 p. Factors which may influence overall transmission range and result in reduction of speeds required are limited access highways with minimum grades and favorable traffic conditions, and more powerful engines with flatter torque curves; gear trains in use: Allison Torqmatic; torque converter in conjunction with planetary gear train.

Dry-Type Air Cleaners on Farm Tractors — Progress Report, J. C. SIEMENS, J. A. WEBER. Paper No. 77A presented Sept. 1958, 14 p. Study of improvement of tractor maintenance, carried out at University of Illinois, divided into three areas: dynamometer tests to determine effects on engine performance of changing from oil bath cleaner to dry paper filter; laboratory bench tests to determine their efficiency, restriction, and capacity, and field tests of paper filters under farm conditions; data and findings.

Clean Air Cleaner without Oil, W. W. LOWTHER, Paper No. 77B presented Sept. 1958, 5 p. Design requirements formualted in SAE test code for oil bath cleaners apply equally to dry cleaners with respect to restriction, air capacity, efficiency, dust capacity and backfiring; details of 5 × 11 in. diam. tri-phase cleaner, developed by United Specialties Co., Illinois, incorporating following stages: inertia cleaning, coarse filtering, and fine or final filtering; application to turbocharged diesel engines.

Application and Performance of Dry Type Air Cleaners on Farm, Construction and Industrial Machinery, F. R. GRUNER, H. L. FORMAN. Paper No. 77C presented Sept. 1958, 11 p. Research work carried out by Purolator Products, Inc., in determining design factors of filters with respect to applications: light duty, medium duty highway, heavy duty highway, and off highway; micronic dry type air filters, made of cotton cellulose impregnated with various types of resins.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.

Readers' Information Service

SAE Papers Available — November issue

- **If you would like complete copies (in multilith form) of papers on which November SAE Journal articles and "capsules" on pp. 78-79 are based, CIRCLE THE APPROPRIATE PAPER NUMBERS in the list below. PAPER NUMBERS are indicated at the END of each article. PRICES are listed below.**

S109	73B	82A	84C	87C	91C	94C
70D	74A	82B	85A	88A	91D	94D
71C	74B	82C	85B	88C	92B	95A
72A	75B	83A	85C	89A	92C	95B
72B	76A	83B	86A	89B	92D	95C
72C	77A	83C	86B	89C	93B	96C
72E	77B	83D	86C	90A	93C	SP-325
72F	77C	84A	87A	90B	94A	
73A	81B	84B	87B	91A	94B	

SP-325 — $2.00 each to members; $4.00 to nonmembers.

ORDER BLANK

TO: Society of Automotive Engineers, 485 Lexington Ave., New York 17, N.Y.

PLEASE SEND ME:

... The SAE Papers and Special Publications whose numbers I have circled above. PAPERS are 50¢ each to members; 75¢ each to nonmembers.

PLEASE SEND ME:

... Information about the advertisers' products and services circled on the back of this form. ☐

.... Check or coupons enclosed ☐

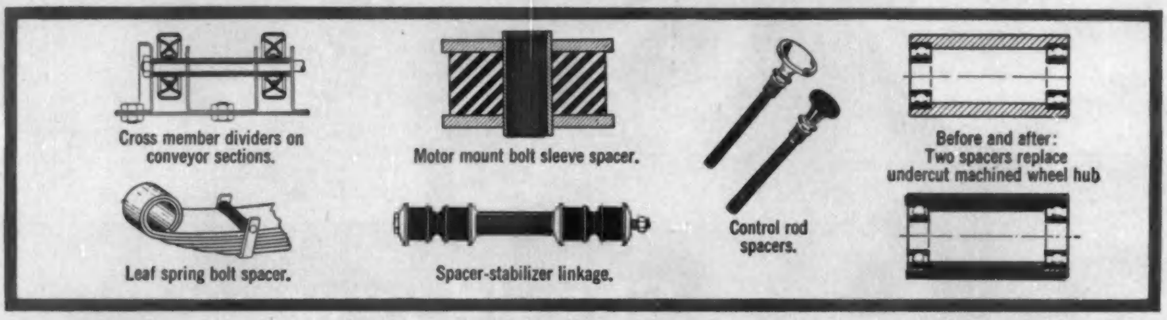
.... Bill Company .... Bill me

NAME ....

COMPANY ....

COMPANY ADDRESS ....

F-M Spacers Save Money in Hundreds of Applications. Spacers shown in Red



SAVE

Time, Money, Materials with Rolled, Split SPACER TUBES

Spacers can effect savings in many manufacturing and assembly operations—from automobiles to pull toys, phonographs to corn pickers. Furnished to your exact dimensions, ready to assemble, they are an economical substitute for iron pipe, tubing or machined parts; eliminate costly cut-off and de-burring machine time; save on secondary operations such as slots, holes, notches and chamfers. In steel, aluminum and stainless. Plain or plated. Many lengths, diameters and wall thicknesses. Complete engineering service.

FREE design data book on standard and special spacer specifications. Address:

FEDERAL-MOGUL DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC.
11035 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

The little booklet on alloy steels that grew into a textbook . . .

Quick Facts about Alloy Steels appeared for the first time in 1956, as a collection of reprints of a series of Bethlehem advertisements in metalworking magazines.

The small booklet was well received, and we kept adding more of the informative advertisements as we reprinted it to keep up with demand. Today, it has grown to 40-page size, and is in its Third Edition. More than 20,000 booklets have been distributed at the written request of executives, engineers, designers, and others, who have found *Quick Facts* to be an authoritative small textbook on the fundamentals of alloy steels. Here's what a U. S. Navy engineer wrote:

"*Quick Facts* is a small textbook of information—a booklet that has been needed for a long time. One of my associates and I had a metallurgical problem involving alloy steels. We just didn't have the information. A friend showed me a copy of your booklet *Quick Facts*, and there on one page, under the subject 'Determining Depth Hardness,' was just what we wanted to know!"

The current booklet contains reprints of the complete series of advertisements, on such subjects as, "What is an Alloy Steel?" "Effects of Elements," "Grain Size," "Heat-treatment," "Quenching Media," and others. It's written in concise, layman's language, from data compiled by Bethlehem's metallurgical engineers.

Would you like a copy of the *Quick Facts* booklet? Just fill out and send in the coupon.

PUBLICATIONS DEPARTMENT, ROOM 1030
BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Please send me your "Quick Facts about Alloy Stee booklet.

NAME ______

COMPANY ______

ADDRESS ______

CITY ______ *STATE* ______

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

How new cushioning medium makes dream seats practical—

How are headrest, back and arm cushioning joined?

AIRFOAM can make them a single, wrap-around unit.

Isn't piping expensive?

NOT WITH AIRFOAM. Molded all-one-piece, it means fewer operations.

I don't like hard edges!

THESE ARE SOFT. Molded in AIRFOAM, they hold their shapes for car life.

Can this bolster hold its shape?

FOR CAR'S LIFE! It's permanently molded AIRFOAM.

Where does the swivel-base mechanism go?

WHERE IT BELONGS. Molded AIRFOAM seat cushions take far less depth than conventional springs and padding.

creates new R-O-O-M, new comfort, new appeal!

LIMITED INTERIOR SPACE needn't limit creative thinking about seating. Not if you utilize the wonderful new *freedom of design* offered by full-depth AIRFOAM.

For full-depth AIRFOAM, molded to your specifications, is an astoundingly versatile cushioning *medium* that eliminates bulky components.

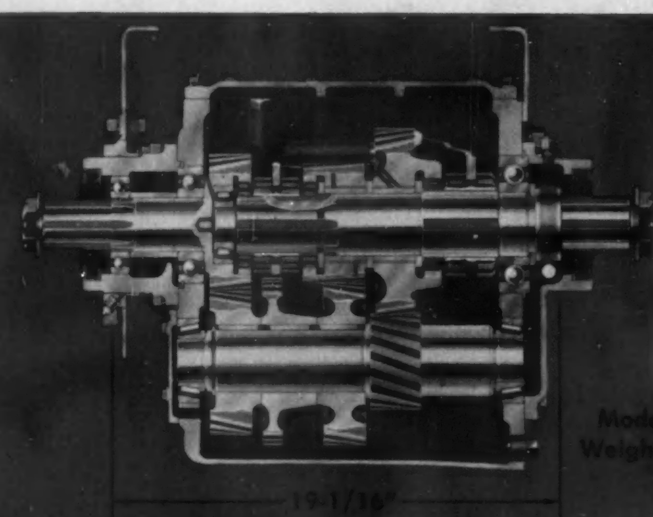
It allows you to do things above and beyond the limitations of old-time cushionings. They're new things—inspiring things—sales-minded things – and because of the unique advantages of AIRFOAM, forever *practical!*

Some of the best names in the industry have benefited greatly by consulting AIRFOAM Development Engineers. May we answer some key questions for you? Goodyear, Engineered Products Dept., Akron 16, Ohio.

Airfoam MADE ONLY BY GOODYEAR

THE WORLD'S FINEST, MOST MODERN CUSHIONING

Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio



Model No.	3-A-65
Gear	Ratio
High	.754
Intermediate	1.00
Low	2.221

Model 3-A-65
Weight—270 lbs.

Now
3-speed AUXILIARY

The Fuller Manufacturing Company now offers the most complete line of three-speed auxiliary transmissions . . . for transport, logging, construction, mining and crane carrier services . . . at lower prices than competitive units in a comparative capacity range.

The extremely rugged heavy-duty 92 Series has been completed by the addition of 5 new sets of gear ratios, Models 3-D-92 through 3-H-92. Four new sets of gear ratios, Models 3-E-65 through 3-H-65, have been added to the popular medium heavy-duty 65 Series.

Split Gears and GO

The expanded line of three-speed auxiliary units includes splitting ratios, both underdrive and overdrive. With these splitting ratios, the engine can operate at maximum horsepower through a full range of vehicle speeds. Ideal for over-highway operation, the extra gears allow faster schedules, greater profits.

Deep Reductions

Deep reductions, in combination with splitting ratios,

92 SERIES (Heavy-Duty)

Model No.	3-A-92	3-B-92	3-C-92	3-D-92	3-E-92	3-F-92
Gear	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
High	.74	.84	.75	.75	.84	.84
Intermediate	1.00	1.00	1.00	1.00	1.00	1.00
Low	2.09	1.24	2.64	1.24	2.09	2.64

FULLER MANUFACTURING COMPANY (Subsidiary, Eaton Manufacturing

65 SERIES (Medium Heavy-duty)

3-B-65	3-C-65	3-D-65	3-E-65	3-F-65	3-G-65	3-H-65
Ratio	Ratio	Ratio	Ratio	Ratio	Ratio	Ratio
.804	.754	.804	.804	.754	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.32	1.32
1.239	1.239	2.221	1.74	1.74	2.221	1.74

...the most complete line of TRANSMISSIONS

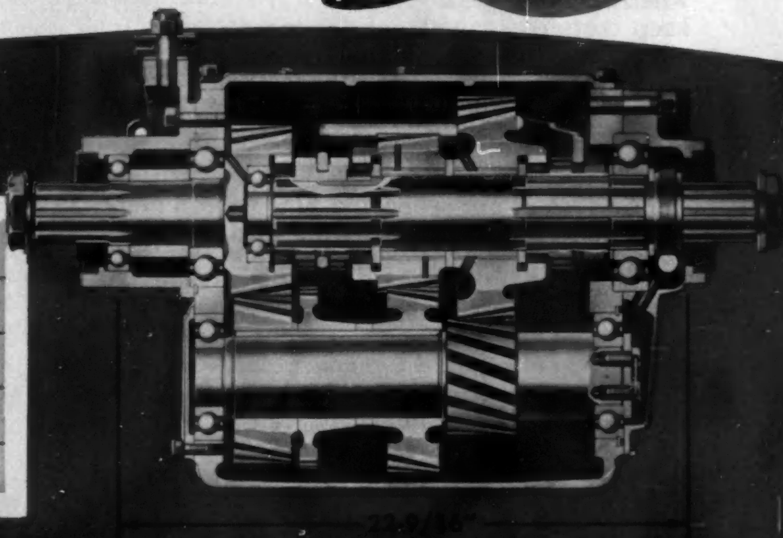
offer maximum flexibility both on and off-highway where the deep reduction is required for extreme grades and soft footing, and where splitting efficiency is required for traffic conditions.

Longer Equipment Life

With engines working in the most efficient torque and horsepower range, there is less lugging . . . less wear . . . and greater fuel economy. Result: lower maintenance costs, less downtime, longer engine and transmission life.

Fuller TRANSMISSIONS ®

Model 3-A-92
Weight—350 lbs.



3-G-92	3-H-92
Ratio	Ratio
1.00	1.00
1.327	1.327
2.09	2.64

Company) Transmission Division · KALAMAZOO 13F, MICHIGAN · U.S.A.

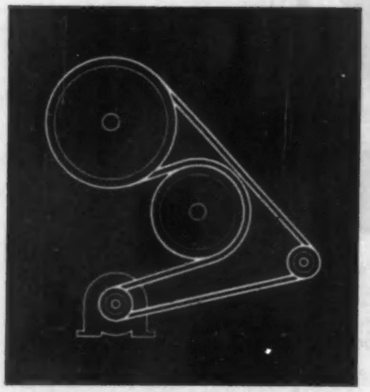

THIS SEAT'S TAKEN...
in one easy turn!
Conceived, designed and produced by Rockwell-Standard Corporation, the remarkable new Swivel Seat* is available on some of America's finest 1959 model cars. It's another important seating development for the automotive industry from Rockwell-Standard Corporation.
*Patents Pending
ROCKWELL R STANDARD
© 1958, R-S Corp.
ROCKWELL - STANDARD
CORPORATION
General Offices: Coraopolis, Pennsylvania

V-Belt Designer's Notebook

A special V-Belt Engineering Service to help you cope with 7 Drive Problems created by space-saving modern design

A checklist of V-belt drive designs which require specialized engineering. With a description of the compensating characteristics which can be built into special Dayton V-Belts. Sources: Case histories from the files of the Dayton Special V-Belt Engineering Service and "The Dayton Handbook of V-Belt Drive Design and Selection."

Here's a typical example of efficient, compact, modern design—an automatic washer with a Dayton V-Belt Drive.

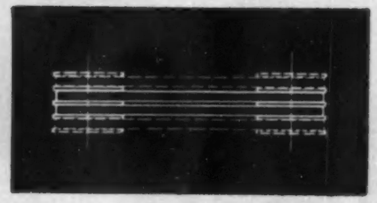


Note that it imposes three design requirements, (1) a torturous back bend (2) sub-diameter pulleys (3) a limited tension take-up area. Yet the design is efficient because Dayton V-Belt engineers developed a belt especially adapted to these three punishing conditions.

You'll find similar examples in machine tools, agricultural machinery and wherever drive space is limited. You've seen them yourself—the designs which dictate sheave misalignment, back-side idlers, underbelting; plus others which use V-Belts as a clutch and which impose excessive shock loads on the belt.

HERE ARE THE MAJOR CONDITIONS WHICH AFFECT V-BELT PERFORMANCE

Underbelting

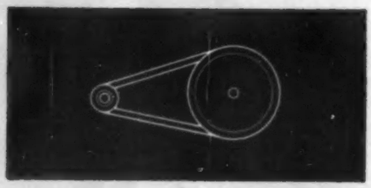


Underbelting is found where space is limited or as a result of very low belt speeds. It will cause belts to slip, run hot and wear out very quickly. A temporary cure, commonly employed, is to over-tension the belt — thus throwing excessive loads on the bearings.

The design requires a high capacity belt with extra-strength cords found in Dayton's Super-Thorobred series or, in difficult cases, belts with both a high coefficient of friction and extra strength like the raw-edge Dayton Cog-Belt.*

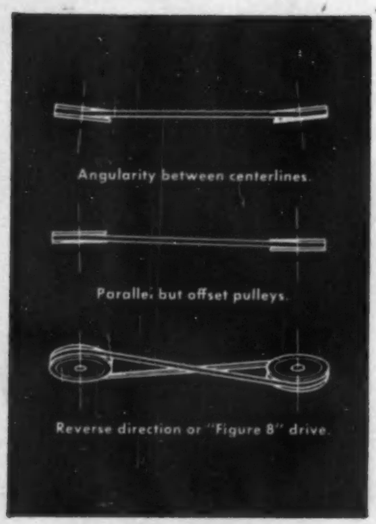
Sub-diameter sheaves

Belts driven by sub-diameter sheaves are inclined to succumb to accelerated flex failure. Tensioning problems are a usual result.



Sub-diameter sheaves require extremely flexible belts for satisfactory service. The required flexibility may be obtained by using thin V-Belts—where drive capacity is not high. When considerable capacity is required, Dayton Cog-Belts will give the most satisfactory performance. Their exclusive design permits exceptional flexibility. Die-cut raw edges provide high coefficient of friction, transmit maximum power from sub-diameter sheave arcs.

Misalignment



Angularity between centerlines.

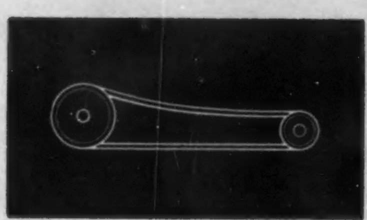
Parallel but offset pulleys.

Reverse direction or "Figure 8" drive.

Misalignment causes uneven tension across the face of the belt—producing abnormal belt and pulley wear and uneven bearing loads.

A suitable approach is to use highly extensible cords of the latest synthetic fibers in the strength band of the V-belt. Dayton's Development Engineer can prescribe the material best suited to your needs.

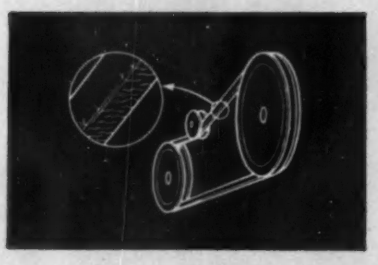
Fixed centers



Proper tension cannot be maintained with fixed centers or where center distance adjustment is inadequate. Without proper tension, belts slip and need frequent replacement.

Dayton V-Belts with low-stretch neutral-axis cords are best suited for applications with little or no provision for center distance adjustment. Still higher performance is gained if the belts have maximum cross-sectional stability which helps keep the belt from seating in the sheave groove.

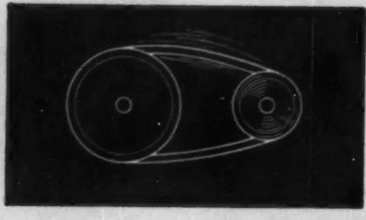
Back-side idlers



Cracks will appear on the under side of the belt, since back-side idlers force the belt to flex in a direction contrary to its construction. Use of spring-loaded back-side idlers may result in belt-snapping.

Where back-side idlers are used to provide tension take-up, they must never be smaller than the smallest pulley in the drive. Dayton V-Belts used in this case employ tension or stretchy type materials in the compression section and have a relocated neutral axis.

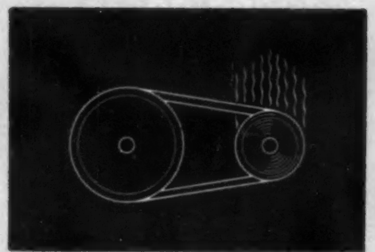
Excessive shock



Excessive shock can cause the belt to snap as well as promote bearing troubles and sheave misalignment.

Belts subject to excessive shock or heavy pulsation require strength band constructions which offer changeable ratios between stress and strain without taking a permanent stretch. Belts with soft cross sections — that will ride up and down in the groove — work well under shock as do wide angle belts. Any of these belts are available from Dayton.

Using as a clutch



V-Belts are ordinarily designed for constant loads and will burn when used as a clutch.

But, belts especially designed for use as a clutch will readily slip when a load is suddenly applied or released. Dayton cover stocks used here have a low coefficient of friction and high resistance to wear.

DAYTON'S SPECIAL V-BELT ENGINEERING SERVICE

Make use of Dayton's Special V-Belt Engineering Service when you encounter any of these designs. Your Dayton V-Belt design engineer is an expert who has devoted himself exclusively to V-Belt Drives. Your design may permit a minor modification which would adapt it to the use of low-cost standard V-Belts. Other standard Dayton V-Belts available for special applications are the Double-Angle V-Belt, the Double Cog-Belt, the Variable Speed Cog-Belt and the Back-Side Idler V-Belt.

With one of the finest research and development laboratories in the industry, Dayton research engineers constantly advance V-Belt knowledge. They develop basic theory, prove the characteristics of the newest compositions and materials available to the rubber industry and test the performance of theoretical constructions. All of this acquired information is at your call when you need a special V-Belt.

Now, while your design is on the drawing board, is the time to call your Dayton V-Belt design engineer. He'll help you select the V-Belt which is tailored to your specific drive. The result — a compact, versatile design which meets all your minimum design requirements and one that will give its users years of trouble-free service.

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis.

***T. M.**

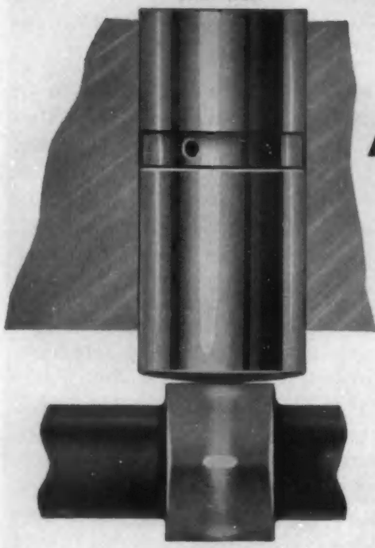
Dayton Rubber

THE DAYTON RUBBER CO., INDUSTRIAL DIV., DAYTON 1, OHIO
WORLD'S LARGEST MANUFACTURER OF V-BELTS

If you haven't received your copy of Dayton's authoritative Handbook of V-Belt Drive Design and Selection, write for it now. Just give us your name, title, and the address of your firm.

Is Your Engine "Horsepower-Limited" by Tappet Face Stress?

THE OLD



CONTACT AREA

Increase

Area of Cam Contact

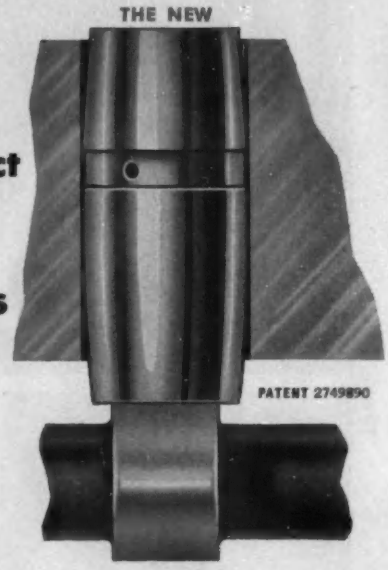
and

Reduce Unit Stress

with

EATON

THE NEW



PATENT 2749890

CONTACT AREA

Flat-Face Self-Aligning Tappets and Hydraulic Valve Lifters

The high cam lifts and heavy valve spring loads involved in developing higher horsepowers place increased stress on cams and tappets. Spherical face tappets make only limited-area contact with the cam, which frequently results in damaging wear or pitting. Flat-face tappets lower the unit stress, but their use has been limited by misalignment and deflection, which cause edge-riding. The Eaton self-aligning flat-face tappet permits full contact between cam and tappet to be maintained under all operating conditions.

Improve your engine by taking advantage of this new Eaton engineering development which has broken through the stress barrier. Call our engineers for a consultation.

EATON

SAGINAW DIVISION
MANUFACTURING COMPANY
9771 FRENCH ROAD • DETROIT 13, MICHIGAN

For the Sake of Argument

Wanted: Solid Senders

Inspiration becomes a living force only when it is inhaled.

The *variety* of means by which humans try to communicate with each other has grown vastly this century. The *volume* of words, pictures, and noises constituting the signs through which inter-person communication is attempted has ballooned tremendously.

But there is little evidence that, as receivers of the signs, we understand the meaning of senders a great deal better than Neanderthal man understood the "Ugh, ugh" of his fellow primitive.

Most of us know what we mean when we say or write something to others. But usually we are far too little concerned with accuracy of reception. We are too prone to assume that our words or pictures are adapted to the reception-requirements of the particular person or people addressed. Information expands in usefulness only as it penetrates the minds of those capable of using it as a working tool. Inspiration becomes a living force only when it is inhaled.

What goes onto a printed page is not nearly so important as what gets from the printed page into the minds of readers. Technical ideas must be understood by nontechnical people before they become of economic and social importance. What goes up must come down; but what goes out doesn't necessarily go *in* anywhere.

Few of us are "solid senders," even in the workaday relationships of our business lives. We might all be surprised with what actually is in each other if more adequate communication were possible.

Norman G. Shidle

Reprinted by request from the July, 1943, issue.

chips

from SAE meetings, members, and committees

CONSTITUTION REVISIONS to implement changes in the SAE structure proposed by the Planning for Progress Committee are detailed on pages 85 to 92 of this issue.

SAE Council welcomes comments on these proposed revisions, particularly within the next 30 days. . . . Discussion of them will be on the agenda at the 1959 Annual Business Meeting of the Society at the Sheraton-Cadillac Hotel in Detroit, Tuesday, January 13, at 8 p.m.

Following the Annual Meeting, the proposed revisions are scheduled for submission to the entire voting membership of the Society by mail ballot.

ON RUSSIAN AUTOMATION, Wayne Worthington of John Deere (recently returned from the USSR) said, "Anything employing mechanical moving of materials is called 'automation'." If a bucket of manure were on a conveyor belt — it would be automation.

"Actually", added Worthington, "the greatest man-hour savers in all Russia are women."

A 10-KILOTON NUCLEAR BOMB (six times more powerful than the first such bomb) will be exploded underground sometime next summer, near Carlsbad, N. M., to gain information on the production of radioisotopes and seismic effects.

ROCKET FUEL ingredients may someday be used to put your blues to flight. A chemical used in making rocket fuel — 1-phenyl-2-propyl hydrazine, or JB-516 for short — has recently been found to be a powerful stimulant against depression and fatigue, at least in laboratory animals . . . and extensive clinical trials are in progress. It has a longer period of effect than the drugs now being used and, unlike the present drugs, does not have a depressing after-effect. In addition, it tends to lower blood pressure and increase the patient's appetite.

SLOW AS OUR PROGRESS is in studying nuclear radiation effects on human beings, we are still about five years ahead of the USSR, according to D. G. Doherty of Oak Ridge National Laboratory.

CARS OF THE FUTURE will have road clearance of 4–5 in. predicts Jack Charipar of Chrysler. Required clearance adjustments will be made available through variable suspensions.

Fuel tanks are expected to occupy unused space within the body and will be elastomeric cells, pretty much like those in aircraft.

CHRONIC EXPOSURE to nuclear radiation may have less effect on human genes than highly concentrated exposure, according to early experiments at Oak Ridge National Laboratory.

AET (*S*-2-AMINOETHYL) ISOTHIURANIUM BROMIDE HYDROBROMIDE) is one of the compounds being suggested to prevent radiation damage in humans. Such compounds appear to reduce damage to blood-forming organs in mice, but their adaptation to human use is being hampered by their toxicity. Unfortunately, no prophylactic action against genetic effects or against deleterious action on non-blood-forming organs has been demonstrated for these compounds.

SCIENTISTS DESCRIBE the ultimate material as practically weightless, infinitely strong, resisting any degree of heat, and capable of being milled, machined, cast, extruded, and forged with great ease and negligible cost. This material hasn't been found yet, but scientists do have a name for it: unobtainium.

SEVEN HOURS — that's the scheduled flying time for the new transatlantic jet service between New York and Paris. And that's 4 hours and 35 minutes less than the scheduled time of the fastest piston-engined aircraft now in service.

A typical flight will depart from Paris for New York at 6:00 p.m. and arrive at Idlewild at 9:25 p.m. the same evening. A flight departing from London at 11 a.m. will arrive at Idlewild at 2:45 p.m. the same day.

Testing an Aircraft Nuclear Propulsion System

Based on paper by

Herman Miller

General Electric Co.

GENERAL ELECTRIC has been testing a complete direct-air-cycle aircraft nuclear propulsion system. The test, known as heat transfer reactor experiment No. 1 (HTRE-1), to determine operating characteristics and to verify the design of the system, has been carried on at the isolated Idaho test site located on the Atomic Energy Commission's National Reactor Testing Station. A schematic diagram of the HTRE power system and test assembly is shown in Fig. 1.

The Idaho test station is divided into three sections — an administrative area, a powerplant maintenance or shop area, and a test area. A power-rail system connects the test and shop areas.

Details of Shop Area

The shop area provides facilities for assembling and disassembling powerplants by manual or remote handling. The machine shop and engine overhaul space are located in the lower bay. Initial assembly of a powerplant is done in an adjacent bay, called the "cold" shop because it is radioactively cold. This is in contrast to the "hot" shop, a room 50 ft wide, 160 ft long, and 60 ft high, surrounded by 7-ft thick concrete walls. In this latter area, powerplants can be assembled and disassembled by remotely operated manipulators, special jigs, and tools. At one end of the hot shop is a storage pool for holding radioactive parts for future use, or to allow the radioactivity to decay prior to further test or disposition.

Radioactive Materials Laboratory

Communicating with the hot shop by a remotely operated plug door is a radioactive materials laboratory, called the "hot" cell, where radioactive components can be viewed through windows and periscopes. A manipulator mounted on a crane bridge will lift from 40 to 750 lb, depending upon the position of the hand. Remote-handling tools

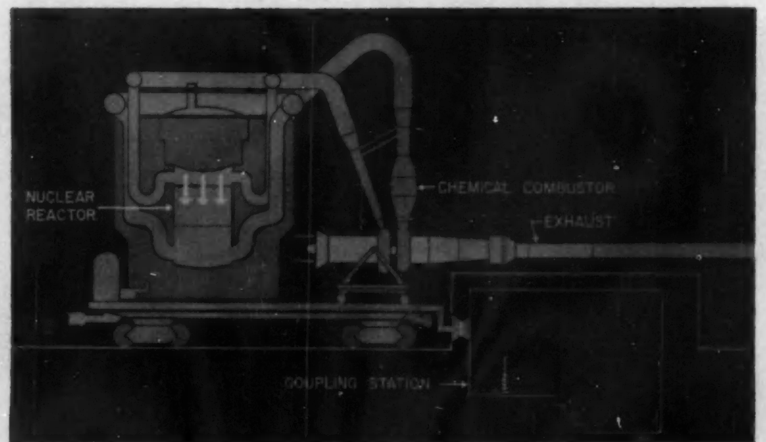


Fig. 1 — Schematic of HTRE power system and test assembly. The entire assembly is shown mounted on a dolly which is hauled between test and maintenance areas by a shielded locomotive (Fig. 3). The coupling station is a small room where the powerplant dolly plug mates with a recess in the facility. The HTRE powerplant consists of an air-cooled, metallic-fuel-element, water-moderated reactor operating a turbojet engine. The turbojet engine and shield are part of the core test facility. The shield consists of water, lead, and steel and does not represent a flight shield. The reactor structure comprises a cylindrical water vessel penetrated by air tubes. Above the reactor is a shield plug for shielding the area above the reactor core from nuclear radiation. Moderator water is used for neutron shielding in the shield plug.

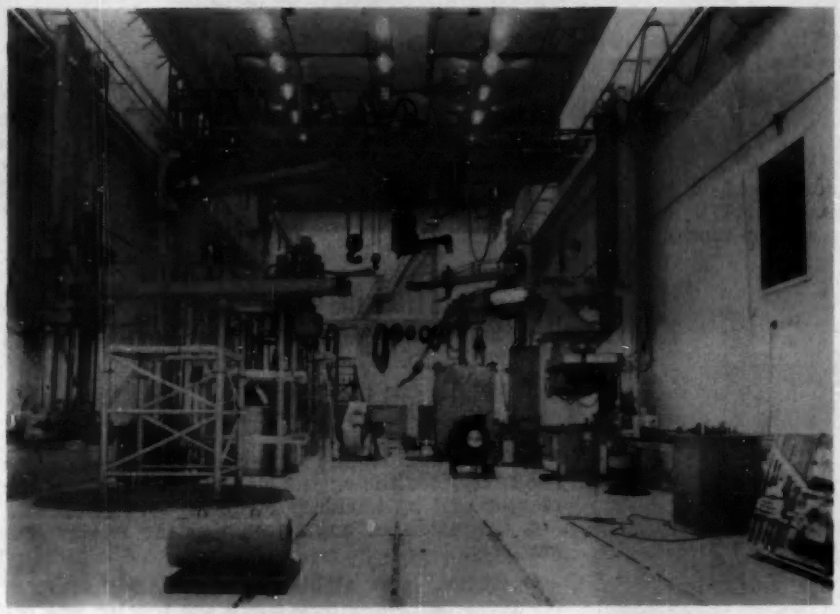


Fig. 2 — Interior view of hot shop, containing overhead crane, turntable, and utility pedestals. Overhead manipulator will lift 500-3000 lb, depending on arm position.

Fig. 3 — Shielded locomotive and dolly carrying power system and test assembly are shown on outdoor turntable. The dolly section is shown schematically in Fig. 1.

include a lathe, milling machine, and grinder, as well as scissors, specimen-mounting presses, canning machine, and a weight balance accurate to a milligram.

Radioactive components are literally "canned up" following examination. They are placed in lead pigs in compliance with radiological safety, and transported to other locations for storage or further inspection or test.

Hot Shop Equipment

The hot shop contains an overhead crane, turntables, and utility pedestals. (See Fig. 2). The last contain outlets for electricity, water, compressed air, and acetylene.

The G.E. designed and built "O-Man" (overhead manipulator) will lift from 500 to 3000 lb depending upon arm position. All manipulators have a variety of hands which permit many different operations.

Shielded Locomotive

A 210-ton locomotive provides power for moving the dolly on which the entire HTRE power system and test assembly are mounted for transportation between test and maintenance areas. Fig. 3 shows

the HTRE and locomotive on the outdoor turntable. Twelve persons can be seated in the shielded cab. Radio communication is maintained from the locomotive to the hot shop and initial engine test facility.

Initial Engine Test Facility

At the end of the initial engine test facility there is a coupling station, a small room where the powerplant dolly plug mates with a recess in the facility. All power leads, process piping, and instrumentation and control leads from the dolly terminate in disconnect fittings on the dolly plug. These connections mate with facility lines in the coupling station. A tunnel connects the coupling area with the main part of the test building.

The powerplant can be observed through two telescopes while it is in operation. One telescope is 60 ft long, and the other 90 ft. The latter is believed to be the longest periscope in the world.

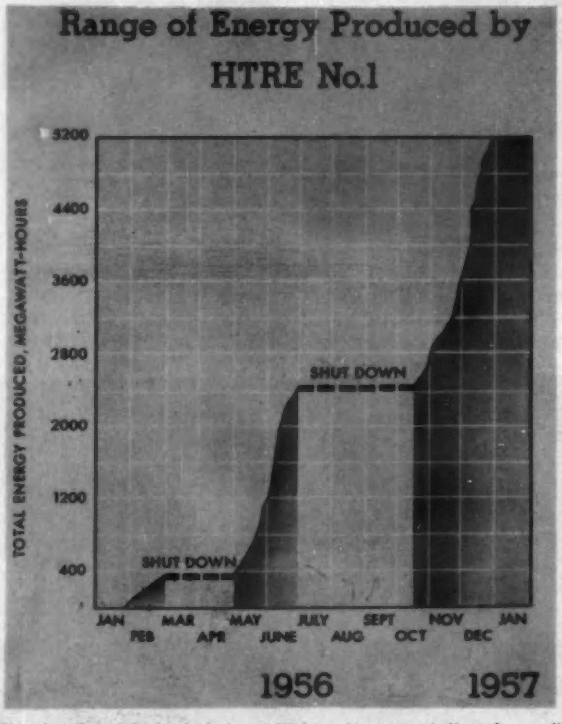


Fig. 4 — Data obtained during initial engine tests indicated overall HTRE-1 system performance to be consistent with design.

How the Tests Were Run

Initial tests were run from December 1955 to February 1956. The operations were:

1. Making the reactor critical.
2. Low power tests in which air coolant was supplied by blowers.
3. Tests with engine supplying coolant air where the energy for the engine was supplied both by the reactor and by auxiliary chemical source.
4. Operation of engine on nuclear energy exclusively.

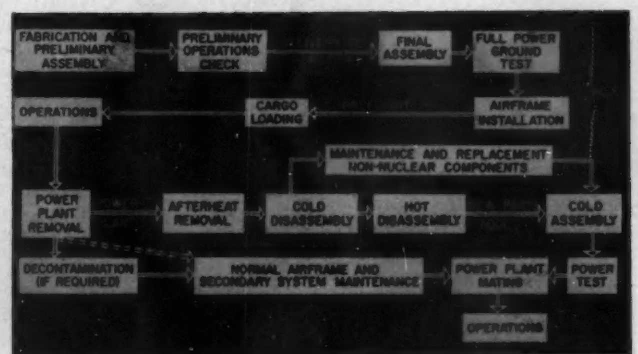
Operation was stable during transition from chemical to nuclear power and the reactor was responsive to both manual and automatic controls. In the first all-nuclear run the reactor-engine system operated successfully for a total of six hours. Fuel cartridge damage occurred in subsequent tests, resulting in a controllable amount of fission product release, and tests were interrupted for examination of cartridges. Three cartridges were damaged, two of them extensively. Repairs were made, operations resumed and continued for 80 additional hours. The corrective action taken restricted the damage to a portion of one element. Subsequently, an identical reactor powered the turbojet engine for longer than the time bogey, thus demonstrating continuous operation equivalent to a mission of long duration. Fig. 4 presents the operating history of HTRE-1.

The schematic diagram (Fig. 5) shows the possible mode of operation for an airborne nuclear powerplant, beginning with its fabrication and preliminary assembly.

To Order Paper No. 92B . . .
. . . on which this article is based, turn to page 6.

Fig. 5 — Here is a schematic of the way an airborne nuclear powerplant might be operated. Upon landing after flight, the powerplant is shut down, but complete shutdown is impossible until provision is made for removal of reactor nuclear afterheat, which represents an appreciable percentage of maximum power. It can be removed by providing power to the compressors from an external source or by an auxiliary air supply.

When the normal overhaul period arrives, the power package is removed and, if necessary, the airframe can be taken to a decontamination station, after which normal airframe and secondary system maintenance can be done by direct contact. The powerplant again requires afterheat removal. Once heat is dissipated, the system may be opened and all equipment external to the shield disassembled. Shield design will make it possible to do most of the work manually if proper precautions are taken to protect personnel. The reactor shield will be disassembled in the hot shop. The shield is to permit removal of the core, after which fuel elements and controls are removed. Some reactor and shield components may be reused.



SAE LOOKS OVERSEAS

By **G. D. WELTY**, Aluminum Co. of America, whose comments result from a recent contact with industries and engineers in Western Europe and in England.

Industrial and economic recovery in Western Europe is an accomplished fact. Never before in history have these countries enjoyed such high levels of production, employment, and general prosperity as prevail there today. Motor traffic and parking problems in the cities are becoming even more aggravated than they are here and traffic density on superhighways exceeds anything to be seen on American freeways, particularly on weekends.

Looking at Germany, one must realize that America no longer possesses the cost advantages of mass production, machinery, and manufacturing methods, which for so many years have enabled us to compete so successfully in world markets against the lower labor costs of European producers.

HIGH PRODUCTION AT LOW COST

Nowhere is this more evident than in the new European automotive industry. Mass production, with all of its efficiencies, has come to Europe, and at labor costs approximately one-third those here in America. This gap can no longer be closed.

We shall, and are, finding it increasingly difficult to sell in European markets (except with foreign aid money), while our own markets become constantly more vulnerable to European competition. This is a matter of gravest concern to many American industrialists. But the implications to date have apparently been lost on our Government, as well as upon the great mass of the American people. That, however, will not be for long, as the growing flood of imports continues to displace American labor.

Intensive automotive research is being directed toward the development of more efficient engines for passenger cars and trucks. Much of this centers around the improvement of aircooled engines employing new designs, materials, and methods of fabrication.

(Continued on next page)

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, M. A. Thorne, chairman

SAE LOOKS OVERSEAS
(continued from preceding page)

The 2-stroke diesel engine, with all of its temperature problems, is the object of much research. Sustained high operating temperatures are being met with very high silicon aluminum alloys. Some of these contain as much as 25% of silicon, and are cast at high temperatures by electric melting and special casting processes. Such pistons are completely finished by the piston manufacturer and are turned to complex contours both vertically and circumferentially with carbide and diamond tools. No grinding is employed.

AMERICAN MARKET EXPORT OBJECTIVE

Aluminum bearings are produced in great numbers on high-speed automatic lines, from extruded tube stock. All main bearings for the Volkswagen are produced in this manner. Light alloy crankcases and brake drums, with liners cast in, are in large-scale production. German automobile and truck production totals at least 4000-5000 units per day, with Volkswagen accounting for perhaps 35-40%. French and Italian production has also reached record levels. The domestic markets are booming but it is to the export market, chiefly the American market, to which they are looking.

One cannot help but feel that the Europeans have a lot to learn about the automobile business and that the lesson, when it comes, will be a pretty painful one. What they don't realize is how quickly the public can turn and what costs are involved in tooling new models for mass production. Model changes never mean much to a European manufacturer turning out 100 cars per week. But when the output is 1000 per day, it's quite another story. This, I believe, will prove to be the greatest pitfall for the new European automotive industry.

By **A. M. BRENNEKE**, Perfect Circle Corp. . . . who returned recently from a trip to Europe during which he talked with scores of automotive engineers in West Germany, Holland, and Sweden.

NEW DESIGNS THROUGHOUT EUROPE

All over Europe, automotive engineering development is going forward on an accelerated basis. New designs and new units cross the vision of the technical tourist wherever he goes.

Typical are those which became apparent on a recent trip to plants in West Germany, Sweden, and Holland:

Daimler-Benz has just launched a new 120-passenger city-model bus . . . . which is being built in their truck and bus production plant at Mannheim. D-B employs more than 10,000 people and produces some 2600 vehicles (and engines) per month. Bus production runs about 200 per month.

International Harvester at Neuss, West Germany, has continued to expand its line of products and now builds its diesel in 3 1/4- and 3 7/16-in. bores . . . in both 2- and 4-cyl models. Soon to be introduced is a large 4-cyl diesel with a mechanical blower. This new powerplant will be rated at 60 hp at 3800 rpm.

1st ALL-NETHERLANDS CAR UNDER WAY

Over at the Hague, it appears, the first all-Netherlands passenger car is in the making. It is being produced by Van Doorne's Automobielfabriek, who has for many years assembled Chrysler products in the Netherlands.

VOLVO designers at Gotenberg, Sweden, are busy on a comprehensive program of increasing the output of their diesels through use of turbosuperchargers . . . and completing design of a new 4-cyl passenger-car engine, using components of their existing small V-8 powerplant.

(Incidentally, the 85-hp VOLVO <u>will</u> run 100 mph. I had a ride in one while visiting in Eskilstuna, Sweden. . . . My hair is a little whiter, I think, but I can testify to the 100 mph!)

In this day of problems of complexity, it was interesting to find SAAB engineers pondering a problem arising from the simplicity of their 3-cyl, 2-stroke crankcase compression engine. American owners and filling station people won't believe that oil <u>should</u> be put in the gas tank!

This automobile division of the Swedish Airplane Factory, created only eight years ago, currently uses a 3-cyl, 2-stroke engine of 38 hp at 5000 rpm. SAAB built 12,000 cars in 1957;is on the way to 25,000 this year — and expects later to level off at 50,000 per year. . . . The SAAB plant is well-tooled with the most modern equipment, and methods . . . and a huge building program, now going on, will by next year have replaced most of the present factory.

At Stockholm, Atlas Copco (making portable compressors for general construction use) has been using "monobloc" compressor units in which part of the cylinders are diesel cycle and the rest compressor cylinders. Now, they have dropped that design for one using separate aircooled compressors driven by aircooled diesels.

HORSEPOWER RACE IN W. GERMANY

In West Germany there is evidence that the American horsepower race is being carried on abroad by American-controlled car manufacturers. One such plant currently has a new, big-bore, short-stroke engine in development for 1960 production.

DC-8 Fuel System is Independent of Auxiliary Power

Excerpts from paper by
M. A. O'Connor and W. B. King
Douglas Aircraft Co., Inc.

THE fuel tank arrangement for the DC-8 is basically an eight-tank system consisting of a main and alternate tank for each engine. A center wing auxiliary tank is incorporated for the over-water configuration, and additional tankage is provided in the wing fillets for still higher weight versions. These variations cover a capacity range of 17,600 to 23,500 gal.

While a four-tank system would be optimum from the standpoint of simplicity, the swept wing design made additional subdivision necessary. Fuel slosh and shift with attitude change would otherwise affect longitudinal stability and control and restrict the loading range of the aircraft. Having lost this round to the weight and balance people, the fuel system designers salvaged their principles by arranging the tankage to function operationally as a four-tank system.

To accomplish this, the fuel tankage is divided equally (within 100 lb) between engines. Each main and alternate tank pair is connected to its respective engine through separate piping. This provides an independent fuel system and fuel supply for each engine. Mechanically actuated selector valves permit direct tank-to-engine feed from either the main or alternate tanks. The individual systems are, in turn, connected through mechanically actuated cross-feed valves to a common manifold to provide complete flexibility of operation between engines. This manifold is also used for ground refueling.

To further simulate four-tank operation, the system is designed such that the engines are supplied directly from the main tanks for all normal operation. An automatic fuel transfer system is provided between each main and alternate tank pair. Fuel in the main tanks is constantly replenished until the alternate tanks are empty. In the inboard systems the main tanks are maintained at the full level. However, in the outboard systems, to keep the fuel mass outboard and reduce the wing bending moment, transfer of the outer wing alternate tank fuel is delayed until the main tanks have dropped to approximately the 7200-lb level. This level is then maintained automatically. In the overwater versions, auxiliary tank fuel is used first and is transferred to all four main tanks through the manifold.

Control of the fuel level in the tanks during transfer is accomplished by means of pilot-float-actuated shut-off valves which, for reliability, are operated hydraulically by the fuel pressure. These components are common also to the refueling system.

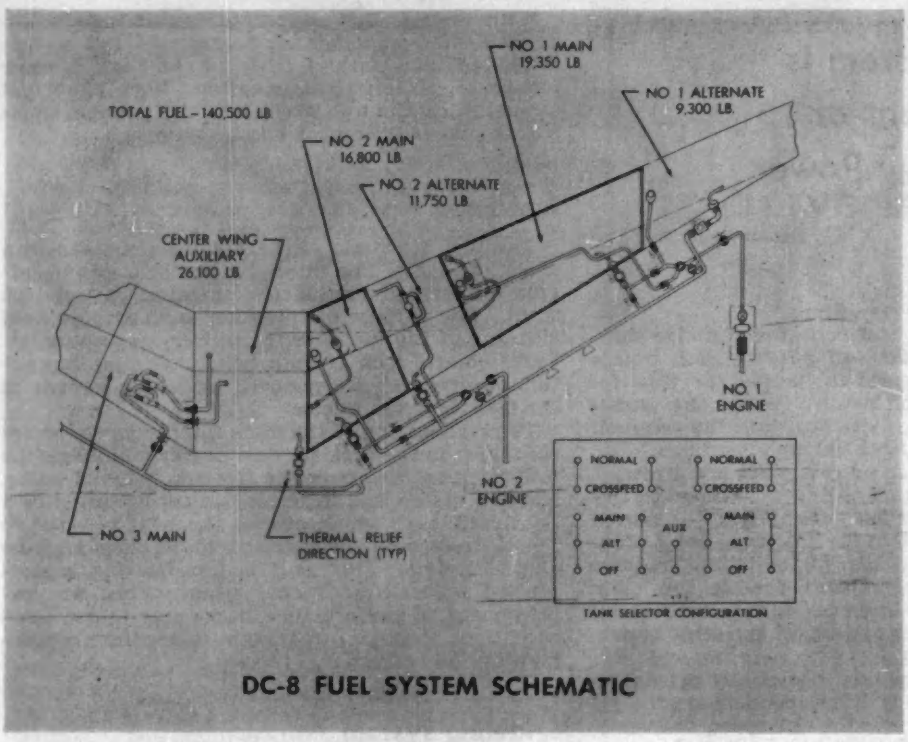
Electric-motor-actuated gate valves are installed in series with the level control valves to provide positive shut-off of the tanks at all times other than during filling or transfer operations.

These are the only electric valves in the entire DC-8 fuel system. Electric valves are acceptable in this particular application because their failure can affect only the ability to put fuel into the tanks. All valves involved in the control of fuel between the tanks and the engines are mechanically actuated, without exception.

More significant than these versatility aspects however, is the fact that control of the distribution system is entirely independent of any accessory power. Hence maximum reliability of operation is obtained.

fuel feed system

The customary tank-mounted booster pump is provided to deliver fuel to the system under pressure. These pumps are a plug-in type, a special de-



DC-8 FUEL SYSTEM SCHEMATIC

velopment for the DC-8. The motor and impeller assemblies of the units can be readily removed and installed through access doors in the upper wing surface without draining the fuel from the tanks. This greatly simplifies maintenance. In addition, the spares problem is minimized in that the motor and impeller assemblies are identical in all tanks. Although the scrolls which incorporate the mounting for the pumps differ in some respects depending on whether the pumping function is that of engine feed or reservoir feed, these assemblies do not contain the rotating parts — hence, are not subject to wear.

The pump motors are explosion proof units. However, to reduce further any possible ignition hazard, thermal protectors are incorporated. Production acceptance test data indicate that these protectors will limit external case temperatures to 200 F and internal temperatures to 350 F. These figures are well below the accepted value for ignition of the fluids involved. In addition, to cover inadvertent operation after the fuel is exhausted, the pumps are designed to permit dry operation for extended periods without overheating and without detrimental effects.

Two pumps are used in the main tanks and are installed in a box or reservoir. This reservoir is provided to maintain fuel at the main pump inlet during periods of adverse attitude when the swept wing configuration causes the low point of the tank to shift from one location to another.

The main pump in the reservoir supplies fuel to the engine under pressure when required and incorporates a bypass to permit fuel to be drawn through the pump with a minimum pressure drop when the unit is not operating. The second pump, termed a reservoir feed pump, scavenges fuel from the low points in the tank during adverse attitude conditions at low fuel levels and delivers the fuel to the reservoir, thus maintaining a full head of fuel over the main pump inlet or bypass. The installation incorporates an automatic selector valve which selects the remote inlet through which fuel is available. This feature permits maximum use of

Coming in December . . .

A description of the reliability concepts of the Boeing 707 fuel system will appear in the next issue of the Journal. This description will be based on a paper (89B) by E. J. Osols of Boeing Airplane Co.

DC-8 Fuel System is Independent of Auxiliary Power

... continued

fuel under all attitude conditions.

The reservoirs hold sufficient fuel for five minutes of operation at take-off power. Both pumps have a capacity adequate to handle the flow for two engines at take-off power. When the pumps are not in operation, gravity flow into the reservoir is admitted through check valves.

In the alternate tanks no reservoirs are provided, and only a single pump is installed. Since the fuel in these tanks will normally be burned out during level flight operation, attitude change is not a problem. Although the function of the pumps in these tanks is primarily to transfer fuel to the main tanks, if necessary the units can also be used to deliver fuel to the engines and are of the same capacity as the main pumps.

Since the tank pumps are electrically driven operation of the engines is still dependent on the reliability of a generator, constant-speed transmission complete with frequency control and oil system, numerous relays and switches, the integrity of several miles of wire, and finally the reliability of the pump motors themselves. It is evident that the objective of independence from accessory systems has not been fully met.

The fulfilment of this objective is found in the Nash engine-driven booster pump which is installed on each engine. This unit is the most important single development in the entire fuel system and constitutes the final step in obtaining complete autonomy. The development of this pump makes possible the use of all fuel in the aircraft at operational altitudes without reliance on tank booster pumps or any source of power external to the operating engine.

Present Douglas reciprocating-engine-powered transports are capable of this type of operation, and contrary to widespread belief in the industry that similar operation with jet engines was impossible, the entire design approach in the DC-8 fuel system was based on the attainment of this capability.

The problem, of course, is that of cavitation and vapor lock of the engine pump due to the evolution of fuel vapor and dissolved air at the greatly reduced pressures encountered at high altitude. Once vapor lock occurs, delivery of fuel to the engine ceases, unless the submerged tank-mounted pumps are in operation. The development of the Nash pump provided the answer.

The missing piece of the puzzle was a vapor-pumping element which was incorporated in the pump. This element is capable of removing free air from the fuel and forcing the air back into solution at the discharge pressure, thus delivering clear fuel to the inlet of the main engine pump, and at the required pressure.

With average fuel temperatures this installation permits take-off, climb, and cruise at full operational altitude without the use of tank booster pumps, and as a normal operation. With 110 F fuel temperature, climb to 25,000 ft is also possible without assistance from tank booster pumps.

fuel filter

The fuel filter and its heater are combined in a single package. The filter element provides 10 micron filtration and has a collecting area of over 1300 sq in. The purpose of this filter is to provide final cleaning of the fuel prior to delivery to the engine. Large objects such as nuts, bolts, and mice (an actual occurrence) are removed by coarse screens at the booster pump inlets.

To prevent icing of the main filter from the water contained in the fuel, the fuel heater maintains the fuel temperature above the freezing point of water. Heating of the fuel is accomplished by means of a heat exchanger which utilizes the heat rejected to the oil from both the constant-speed drive and the engine systems. Not only is fuel heating accomplished without additional penalty, but an improvement in performance is possible under some conditions through a reduction in required supplementary oil cooling.

refueling system

The refueling system for the DC-8 combines maximum safety and reliability with operational simplicity and is capable of an initial filling rate of approximately 1400 gal per minute.

The aircraft is refueled through four pressure filling points located, two on the under side of each wing, between the inboard and outboard nacelles. These fill points are connected to the main manifold. Fuel from the manifold is admitted to the tanks through the motor-actuated gate valves and level control components. These features are identical for each tank. To facilitate maintenance, check valves are provided to permit removal of the level control valves and other components without draining the fuel from the tanks.

The level control valves for the DC-8 system were specially designed to fail to the closed position. In other respects, however, these valves are similar in construction and operation to the more standard fail-safe fail-open components. The valves are operated by pilot float valves located at the full level in the tanks. When the full level is reached, a small bleed flow from the level control valve is shut off, resulting in equalization of pressure across the operating diaphragm which closes the valve. Provisions are made for checkout of all components of this system.

To check operation of the level control valve, fuel is introduced into a chamber surrounding the pilot valve float, thus simulating the full tank level and inducing the normal system response. In the event of valve malfunction in the open position after checkout and during refueling, the vent system has been sized to accommodate the full fuel flow into the tank without resulting in excessive pressures.

Complete control of the refueling operation, in-

cluding checkout of the system, is accomplished from the cockpit fuel management panel. To facilitate filling to partial tank levels, a settable bug is provided on each tank quantity gage. Switch contacts in the back of the indicator close when the set quantity of fuel has been reached and actuate the motor driven gate valves at the tank inlets. This installation permits presetting of the desired fuel quantity in each tank, and after this has been accomplished the refueling operation is automatic. Those tanks which are to be completely filled are normally shut off by the pressure-actuated level control valves.

To accommodate refueling in the absence of pressure refueling equipment, standard overwing fill points are also provided.

fuel dump system

In keeping with the philosophy of minimum reliance on accessory power for operation, a gravity fuel dumping system has been provided. To avoid compromising the integrity of the fuel supply system, the piping and systems are completely separate. Fuel dump valves are provided in each tank and are of the type used for many years in the DC-6 and DC-7 aircraft. The outlets from the valves in each wing are connected to a separate manifold and dump chute. For maximum reliability, all valves are mechanically actuated and are operated by extension of the dump chutes to preclude inadvertent opening with the dump chutes in the retracted position. Although extension of the chutes for fuel jettisoning is normally accomplished electrically for ease of operation, provision is also made for mechanical extension.

The design of this system permits the jettisoning of fuel at approximately twice the rate required by the Civil Aeronautics Administration. This permits reduction to landing weight for the overwater airplane in approximately 20 minutes by the jettisoning of 97,000 lb of fuel.

fuel vent system

The fuel vent system for the airplane is a simple manifold system in which the individual tank vent lines are connected to a single 4-in.-diameter manifold in each wing. To accommodate the change in the high point of the tanks during attitude change with the swept wing design, two vent lines are installed in each tank to cover the full range of attitude conditions. Fuel vent boxes are provided at the manifold vent outlets, in each wing tip, to preclude loss of fuel which may be introduced into the system during attitude changes. Drain valves are also provided at the inboard end of the manifold to return any fuel contained to the aircraft tanks. These valves, however, can in no way affect tank venting.

Complete paper on which this article is based also describes development of protection against icing of fuel system components and determination of adequate suction feed capability.

To Order Paper No. 89A . . .
. . . on which this article is based, turn to page 6.

Designing Cars To Serve the Public

Based on talk by

James W. Watson

American Motors Corp.

(Presented before SAE Cleveland Section)

THE U. S.-built car could be improved in a number of ways if the public interest were made the primary consideration. Here are some of the possible design changes:

- Better rear-view vision is needed. Present mounting of mirrors obstructs forward vision and is inadequate for vision behind.

- Front seats should be split two ways and possibly three ways to give more comfort to individual occupants. Greater adjustability is needed both in front and rear seats.

- Economy of operation is a public need. Scientific design could give cars of lighter weight with adequate roominess, comfort, and appearance.

- A reduction in overall length and shorter turning radius would increase maneuverability and make for easier parking.

- Recent horsepower and top speed increases have not been in the public interest. What is needed is balanced performance — sufficient power to attain safe, sensible, and legal speeds, and adequate acceleration.

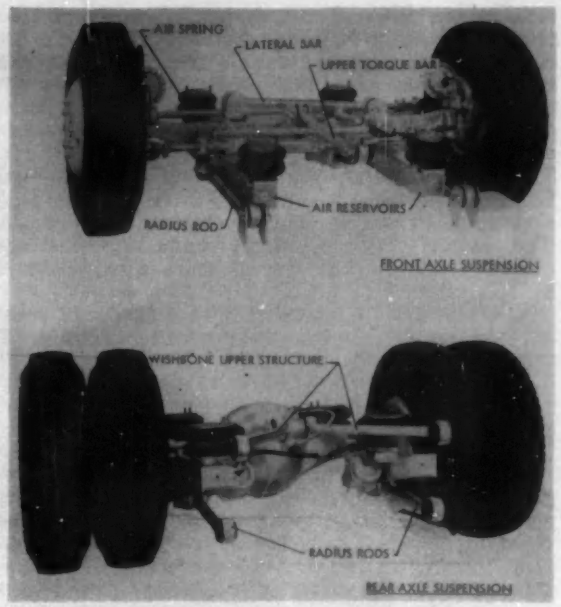
- Balanced performance means designs which improve accessibility and reduce service costs.

- Radical annual style changes accelerate obsolescence. The public is showing increasing resistance to the industry's program of "planned obsolescence." It may boomerang and ultimately slow sales. A return to the classic style of simple lines is in order.

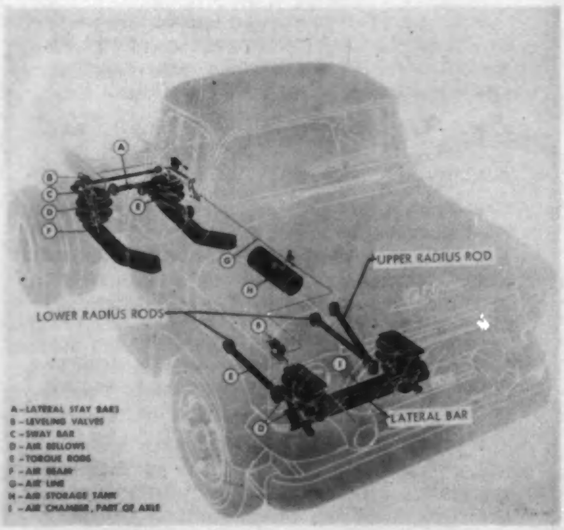
- The present choice of models is too limited. The need is for more of the smaller, less costly, more sensible models.

8 Types of Air Suspensions For Trucks, Trailers, and Buses

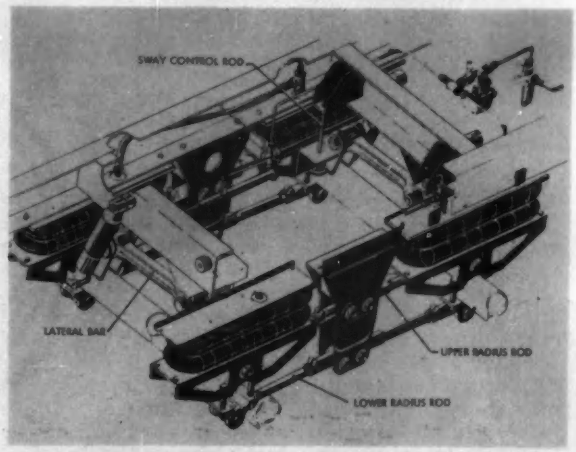
Based on paper by **W. E. White** Clark Equipment Co.



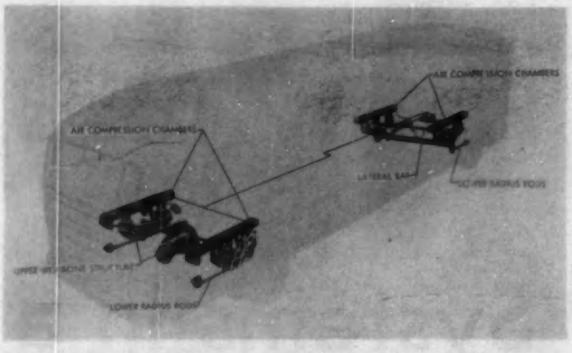
FRONT AND REAR AIR SUSPENSION for buses by Mack Mfg. Co. uses double convolution type air springs supported on structure also serving as air reservoirs or compression chambers. Lower radius rods, lateral bar, and upper torque bar provide longitudinal and lateral axle positioning and torque control on front axle. Wishbone structure on rear suspension combines function of lateral and upper torque bars used on front. Three leveling valves are used, one on front, two on rear. Each axle has two direct-acting shock absorbers. All lubrication points are eliminated.



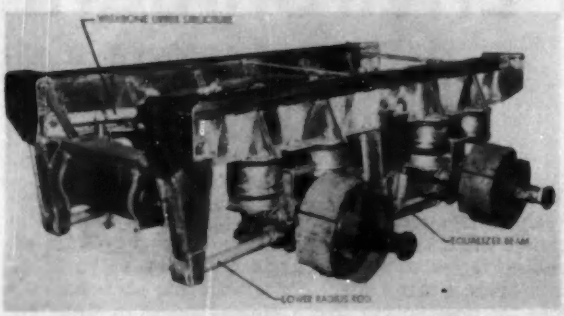
REAR AXLE of GMC truck suspension is supported by two air springs. Axle is positioned by rear air beams, which act as compression chambers, an upper torque rod, and rear lateral bar. U-shaped sway or stabilizer bar aid springs in resisting roll. Front axle is positioned by two lower radius rods, one upper rod and a lateral bar. Front air beam is integral part of front axle. One height control valve is used for front suspension, two for the rear. Front and rear have direct-action shock absorbers. No lubrication is needed.



AIR SUSPENSION of tandem type for trucks, trailers and buses by Spencer-Safford Loadcraft, Inc. Springs are double convolution pillow type, four per tandem. Axles are positioned by upper lateral bars and combination of adjustable upper and lower radius rods which also absorb starting and braking torque. Sway is controlled by four sway rods mounted directly inboard from each spring and adjacent to axles. Each set of air springs has a leveling valve. Damping is by four direct-acting shock absorbers. Bushings eliminate lubrication.

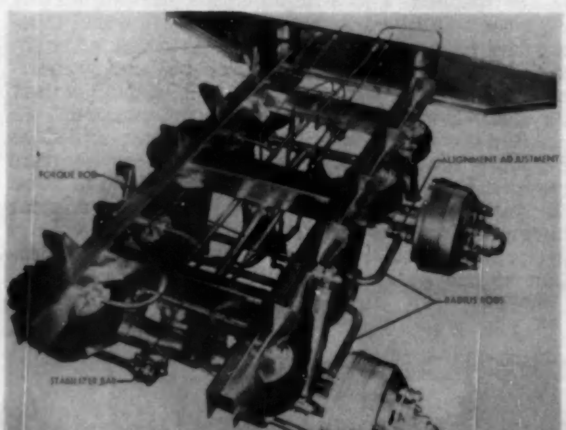


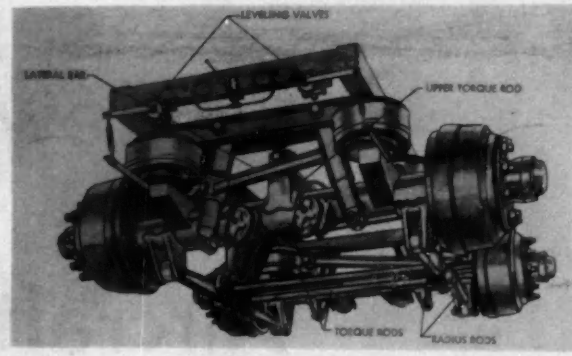
BUS SUSPENSION using double convolution bellows type air spring for each axle is GMC design. System employs height control valve. One centrally located valve is used on front suspension, and two valves, one on each side, on rear suspension. Lateral axle positioning and torque control are effected by combination of upper wishbone structure and lower radius rods on rear suspension; by lateral bar and lower radius rods on front. No lubrication.



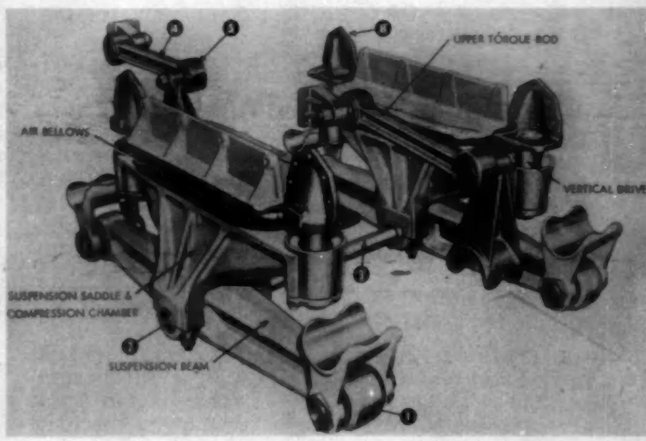
TRAILER TANDEM AIR SUSPENSION BY KRAUSE Corp. uses lobe or double convolution type of air spring. Leveling valves on either side of suspension are conventional. Torque reaction and some lateral axle control is obtained by upper wishbone structure. Radius rods provide additional lateral control. Equalizing beams function as rear axle radius rods as well as equalizing load between two axles. Rubber-mounted rebound limiting rods are said to provide sway control. No lubrication is required.

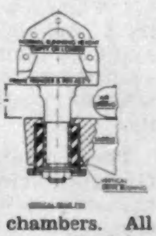
AIR CONTAINERS of the Clark "Cushionaire" tandem suspension are the round double convolution type. Four springs on each side are served by a manifold to equalize pressure. Each manifold is served by a frame-mounted leveling valve. Lateral position of axle is controlled by stabilizer bar and U-shaped radius rod. Rod also maintains longitudinal axle position with aid of upper torque rod which absorbs braking torque. Body sway is controlled by wind-up in radius rod. Damping is by direct-action shock absorbers, two per axle. No lubrication required.





TRAILER SUSPENSION by Clark Equipment uses lobe type air containers. Leveling valve incorporates hydraulic damping for time delay. Two frame-mounted valves are used, one for each bank of four air springs. Lateral location of axle is controlled by a bar attached to axle and suspension framework, or trailer frame. Braking torque, sway, and longitudinal axle location are provided by a combination of upper torque rods and lower combination of radius and torque rods. Direct-action shock absorbers provide damping. No lubrication needed.





TANDEM SUSPENSION for truck and trailer by Hendrickson Mfg. Co. has vertical rubber-mounted drive pin design. Pin design with upper torque rods functions to absorb starting and braking torque as well as to position axle and control sway. Axle articulation is accomplished by equalizing beam to which axles are attached. One leveling valve is used on each side of suspension. Saddles which support beams also serve as compression chambers. All major structural parts are made of aluminum. Need for lubrication is eliminated.

To Order Paper No. 73A . . .
. . . on which this article is based, turn to page 6.

New Facility Tests Aircraft Systems in a Radiation Environment

Excerpts from paper by

M. M. Miller and A. M. Liebschutz

Lockheed Nuclear Products, Georgia Division, Lockheed Aircraft Corp.

A FACILITY for the evaluation of dynamically operating aircraft systems, Air Force Plant No. 67, is being constructed about 60 miles north of Atlanta, Georgia under Air Force Contract by Lockheed Aircraft Corp.

This laboratory is planned to satisfy some rather specific requirements. It must:

1. Provide for dynamic testing of aircraft systems in realistic radiation fields; that is, in fluxes comparable to, and in some cases in excess of, those that are expected to fall on the particular system at its most likely location in a nuclear-powered aircraft.
2. Have the ability to handle large test articles rapidly.
3. Possess adequate handling and testing capability. It must be possible to move large test articles to and from the reactor safely with means provided for evaluating them before, during, and after irradiation without exposing personnel to excessive radioactivity.

These requirements are met at AFP No. 67, The Georgia Nuclear Aircraft Laboratory. Fig. 1 shows the site plan with insets of the two major laboratory areas. Test articles are moved between these areas by the Hot Materials Transportation System, a standard-gage railroad using a manned locomotive and specially designed test cars that are 10 ft wide and 15 ft long, and which can support a 15-ton test article.

By necessity this laboratory incorporates some rather unusual features. Perhaps the most novel of these is the method by which the Radiation Effects Reactor is operated. This reactor is of the well-known MTR type, light water cooled and moderated and designed to operate at 10 megawatts. In order to provide a large space for irradiation and easy access for positioning test articles in a high flux, the reactor is situated so that it can be raised from the pool to perform its irradiations at ground level. This arrangement permits the moving of test articles into the reactor area on railroad cars while the reactor is shielded by the pool. The movement of the reactor, its operation, and the recording of test data are all accomplished from the underground control room adjacent to the reactor building.

Remote handling facilities at The Georgia Nuclear Aircraft Laboratory consist of a hot cell mockup and a row of four hot cells. All cells are equipped with Argonne Model 8 manipulators, and the mockup and two of the hot cells are fitted with a General Mills Model E-2 manipulator. Remote viewing in all cells is accomplished by the use of windows, periscopes, and closed circuit television. Special equipment has been included in the hot cells for testing electrical, electronic, electro-mechanical, hydraulic and pneumatic systems, and components. In conjunction with the remote operations complex are warm laboratories for detailed inspection and testing after induced activity has sufficiently decayed and supporting laboratories such as chemical, radiochemical, physical testing, and nuclear instrumentation.

After the test item is designed and assembled its probable dosages analysed, and its test program mapped, it is mounted on a panel fabricated to fit on the railroad test car. The functional and nuclear instrumentation is installed and functional tests are performed. This instrumentation includes in addition to the nuclear dosimeters, transducer equip-

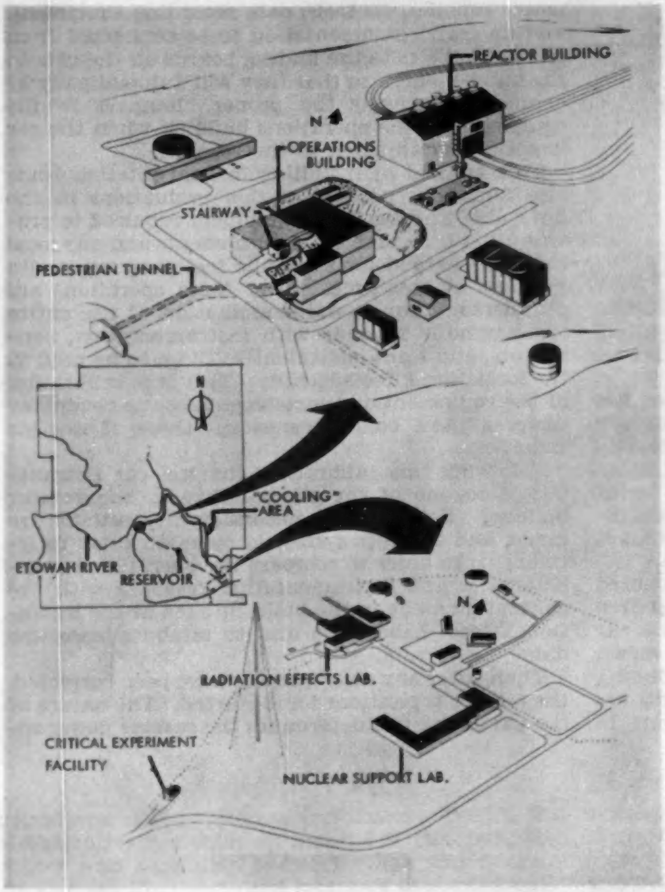


Figure 1

GEORGIA NUCLEAR AIRCRAFT LABORATORY has a Reactor Building surrounded by supporting facilities and some distance away a Radiation Effects Laboratory for post-irradiation evaluation of systems under test. Preparation of test systems is also accomplished at Radiation Effects Laboratory.

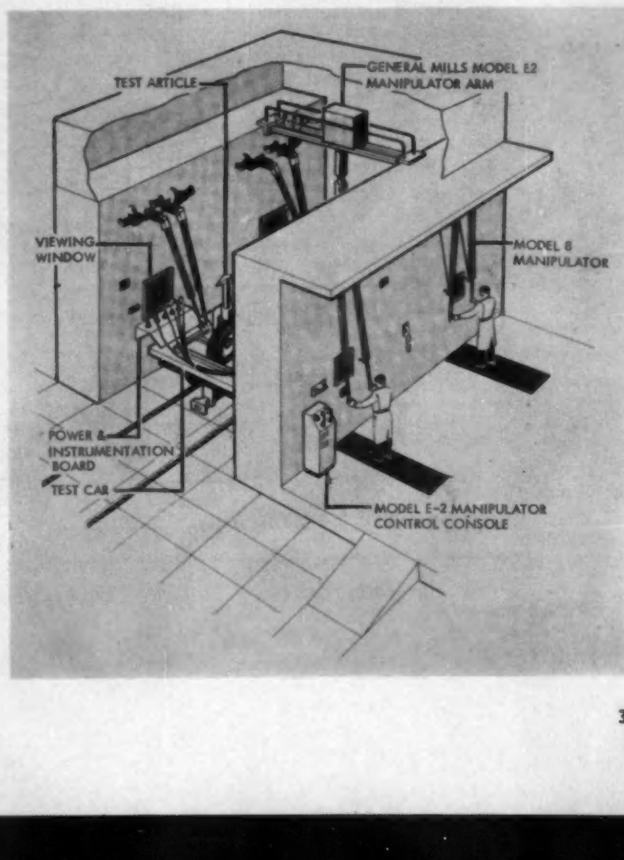


Figure 2

HOT CELL MOCKUP duplicates hot cell at reactor except for shielding. Test pieces are tried here to make sure they can be disassembled and tested in the reactor hot cell.

New Facility Tests Aircraft Systems in a Radiation Environment

. . . continued

ment which measures such variables as temperature, flow, viscosity, pressure, vibration, rotary speed, rotary position, frequency, voltage, current, phase, linear position, and linear acceleration.

Once the test system with its instrumentation has been adjusted for proper operation, the hot cell mockup (Fig. 2), which duplicates the disassembly hot cell except for shielding, is used to make certain that the test article can be disassembled and tested in the hot cells. The test article is then re-assembled and another functional check made before it is transported to the Radiation Effects Facility.

The test panel containing the system is mounted on a railroad test car in the systems build-up area of the Radiation Effects Laboratory. Each test car is equipped with a mating board arranged as shown in Fig. 3 for remote operation with its corresponding member at the Radiation Effects Facility. This arrangement permits the leads for connections to power supplies, controls, data recording equipment, and nuclear instrumentation to be connected from the test articles to the mating boards on the cars in the build-up area so that they will automatically be connected through the proper channels to the equipment in the operations building when the car is positioned adjacent to the reactor.

This method of installing instrumentation leads also facilitates post-irradiation evaluations in the hot cells. The auxiliary equipment required to provide other than ambient environments and any local shielding needed for a specific test program is also installed at this time. After these operations are completed, a functional examination of the entire test assembly is made with instrumentation, connectors, and leads equivalent to those to be used at the Radiation Effects Facility. This final calibration of the equipment and instrumentation is conducted under all test conditions except those of nuclear radiation.

Following this calibration, the test car is transported to one of the six positions in the reactor building (Fig. 4). All necessary connections are made, and the test system is operated prior to irradiation in order to compare the operational characteristics and instrumentation response with the calibration made in the build-up area at the Radiation Effects Laboratory and to establish base-line data.

Then, after any discrepancies have been corrected, the reactor is positioned and started. The nature of the particular test determines the reactor power re-

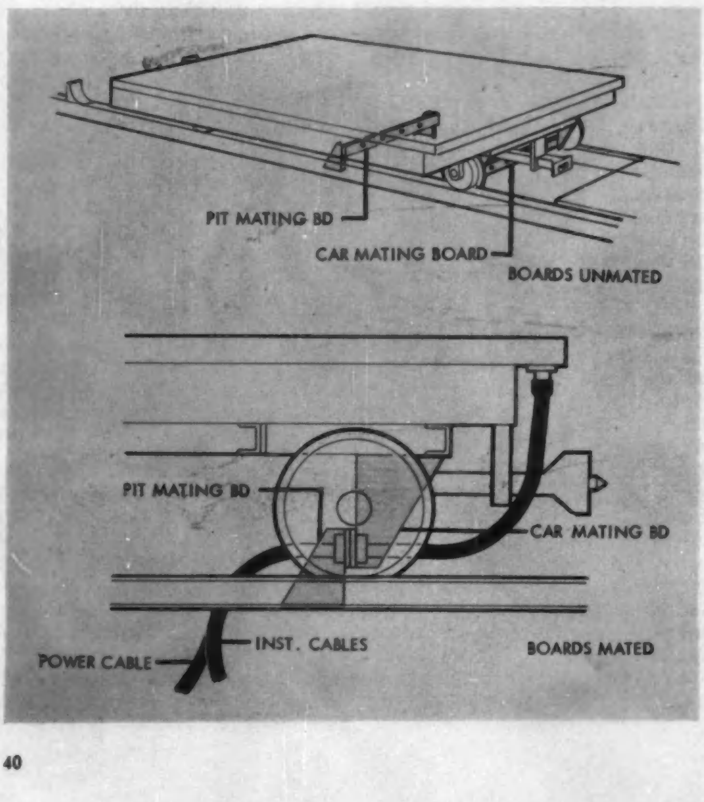


Figure 3

RAILROAD CARS FOR TRANSPORTING TEST PIECES AROUND THE SITE incorporate mating boards for automatic connection of leads at the reactor.

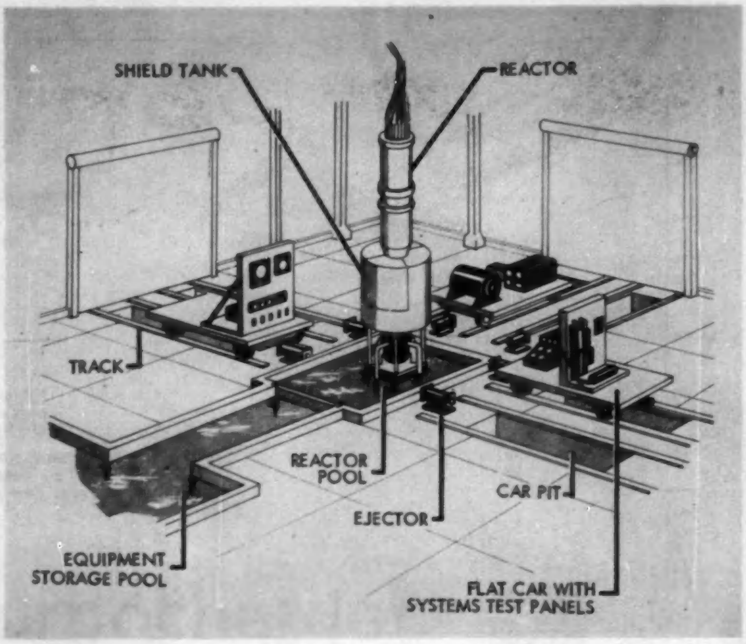


Figure 4
REACTOR has two sets of tracks for test cars at each of three approaches.

quired and the duration of irradiation. During irradiation, values from all monitored channels, together with such data as reactor flux and nuclear parameters from pertinent locations in the test system, are recorded as a function of time. Electronic equipment in the operations building is used to record dynamic data, and cycling is accomplished as desired on a prearranged schedule throughout the test period. Data processing and reduction is conducted on a continuous basis by means of visually inspecting the recordings from each monitored channel and then extracting and plotting pertinent data.

During a period of irradiation, the reactor is scrammed at the end of each shift and lowered into the pool. This shift change requirement dictates a schedule for the reactor of 6 hr of operation, followed by 2 hr of shutdown. After completion of an entire irradiation, test assemblies are left in place for a period of time to permit decay of short-lived induced radioactivity. Any desirable post-irradiation testing is conducted during this interval.

Nuclear measurements are made to determine activition levels of the test article and car. When these have been sufficiently reduced, the car is remotely ejected from the building and allowed to roll down the slight grade of the tracks far enough to be safely connected to the manned locomotive and moved either to the cooling area or to the hot cells. Several empty cars are interposed between the locomotive and the test car to provide adequate separation for the attenuation of the radioactivity to a level that is safe for the locomotive operator.

After the car is moved into the hot cell the test article is dynamically tested to determine the degree of recovery, if any, of components that have completely or partially failed during irradiation. Power and instrumentation loads are connected to a junction board in the disassembly hot cell to allow monitoring of the irradiated article with instrumentation duplicating that previously used. At the same time, the operation can be observed through the windows or with the aid of the television system or the periscopes.

Items exhibiting a tendency toward post-irradiation recovery or those for which activation decay characteristics are desired may be checked in the hot cells and returned to the cooling area for as many cycles as required prior to disassembly. Following these tests, damaged components are removed from the test panel, decontaminated, disassembled, and transferred to the appropriate work area for further analysis. Items with sufficiently low activity are transferred to the warm laboratories for detailed study. But if the activity is excessive for the warm laboratories, tests and analyses are conducted in the hot cells.

As a final step in the testing procedure, data recorded and processed during the irradiation are combined with both pre- and post-irradiation data for analysis of the effects of radiation on the condition and performance of the test article. These results are also correlated with the theoretical preanalysis made in connection with the design of the experiment.

To Order Paper No. 92C . . .
. . . on which this article is based, turn to page 6.

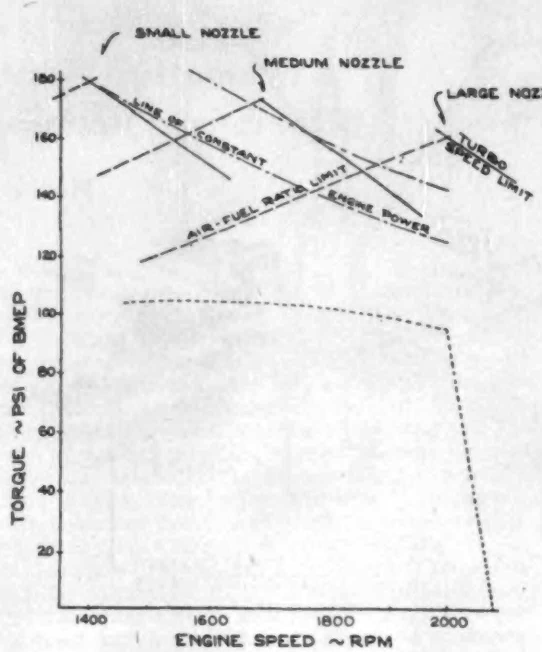


Fig. 1 — Three turbocharger matchings for the same engine. The peak on the right is produced by using a large area turbine nozzle. The matching peak on the left is produced by a small area nozzle. The middle peak represents the compromise offered by a medium nozzle size.

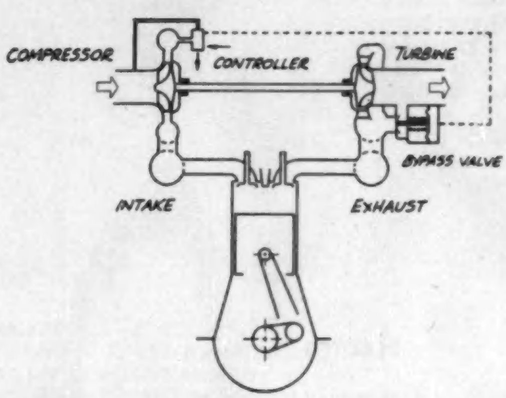
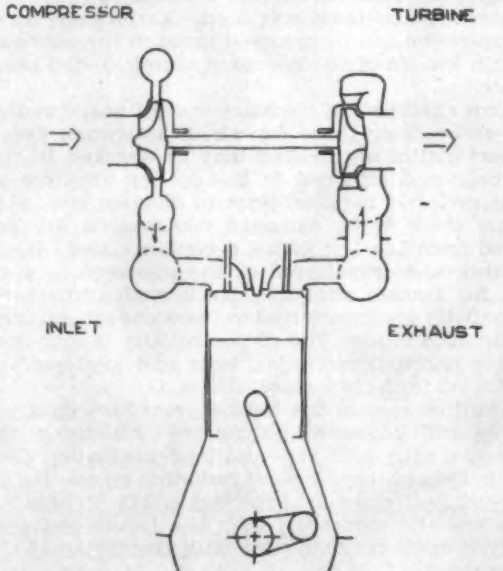


Fig. 2 — Typical pressure-ratio controlled turbosupercharger. The controls keep the output of the turbocharger compressor at a constant pressure ratio over a wide range of engine operating conditions.

Selecting

Here's How the Turbocharged Engine Works



Engine exhaust gas from the exhaust manifold powers a turbine which drives a centrifugal compressor. The compressor compresses atmospheric air and delivers it to the engine, thereby supercharging the engine. The wheel of the turbine and the impeller of the compressor are mounted on a common shaft. There are no mechanical connections to the engine.

The centrifugal compressor of the turbocharger consists of two elements, the impeller, or rotating part, and the diffuser. All the work is done on the air by the impeller and about half of the pressure rise takes place in it. The diffuser converts the velocity head of the air into the remainder of the pressure rise.

The turbine of the turbocharger also consists of two elements, the nozzle and the wheel. The nozzle is a ring of small openings aimed inward to produce a spiral or vortex flow of exhaust gas. Because the nozzle openings are small compared to the volume flow of the exhaust gas, a vortex of high velocity is formed. The turbine wheel is mounted inside the nozzle vortex flow and is driven by it.

The speed of the turbine is determined by the velocity of the nozzle vortex flow and by the power drawn from the turbine. All other things being equal, small nozzles drive the turbocharger to higher speeds, large nozzles produce lower speed. This action provides a principal means of matching the turbocharger to the engine.

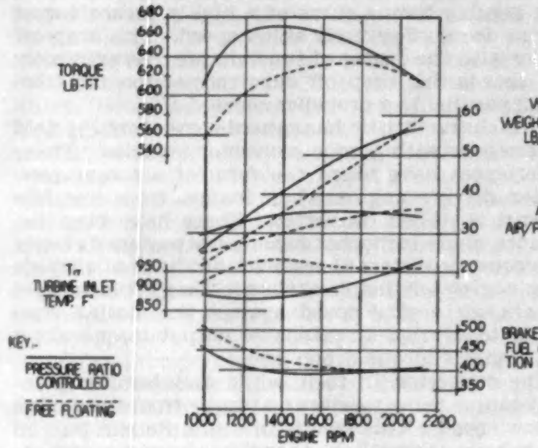


Fig. 3 — Comparison of turbocharged diesel with and without pressure ratio control.

the Right Turbocharger

for a high-speed diesel engine requires an analysis of the engine, ambient conditions, and the control system.

Based on paper by

Wilton E. Parker

Manager, AiResearch Industrial Division, The Garrett Corp.

IMPORTANT considerations in matching turbochargers to high-speed diesel engines are:

1. The type of service for which the engine will be used.
2. The type of control system which will be used for both the engine and the turbocharger.
3. The ambient temperatures and pressures to which the engine will be exposed during operation.

A common practice is to compare turbocharger performance by comparing only the merits of compressor charts. This sort of a comparison, though often valuable in selecting the proper size of turbocharger for a given engine, can lead to erroneous conclusions. Further, a comparison based solely on the comparison of component (that is, turbine, compressor, and mechanical) efficiencies can likewise be misleading. Best performance depends on component efficiencies being high at the same engine operating point.

Much stress has recently been placed on the value of turbocharger acceleration. This is a debatable criterion as a figure of merit. What is more important is the condition or time at which the turbocharger reaches the cross-over point (the operating condition at which compressor exit pressure equals turbine inlet pressure).

After the cross-over condition is attained, a pressure differential exists which promotes good scavenging, lower exhaust temperatures, and better overall engine acceleration with less smoke. Good component efficiencies coupled with properly matched components will create this desirable condition. Until this condition is reached, maximum engine acceleration cannot be attained without excessive smoke regardless of turbocharger acceleration characteristics.

Effects of Engine Usage

Fig. 1 shows three basic turbocharger matchings for the same engine. The peak on the right is produced by the use of a large area turbine nozzle which requires high engine speed and high exhaust temperature (high torque) to produce a high nozzle vortex velocity.

The matching peak on the left is produced by the use of a small area nozzle. This nozzle produces a high nozzle vortex velocity at high exhaust temperature (high torque) even at low engine speed.

The middle peak is the compromise offered by a

medium nozzle size.

These sample curves illustrate that the engine designer has available a choice of torque curves to fit his special needs. The curve on the right is a typical propeller-type matching. It is used by ships, by railroads, and by electric powerplants. The middle curve would be very effective with "stiff" torque converters in pusher tractors or wheel tractors. The curve on the left should be of advantage with geared tractors or front-end loaders.

As an engine is more highly supercharged, its response rate becomes progressively more dependent upon the response rate of the supercharger. For example, a zero degree supercharged engine (naturally aspirated) needs no supercharger response to provide full change in torque on demand. A 50% supercharged engine can furnish about 100 bmep torque instantaneously upon fuel injection and relies on the supercharger to make the last 50 bmep available. For the 100% supercharged engine, the first 100 bmep is independent of supercharging; the last 100 bmep is dependent upon supercharge. The proportions have become 50% of torque instantly available, 50% dependent upon supercharging action. Thus, the highly turbocharged engine has characteristics which are a cross between the response characteristics of the naturally aspirated reciprocating engine and the gas turbine.

A number of avenues of development are open to the solution of this problem. One, the response rates required of the powerplant can be minimized. Torque converters operate in this direction. As another approach, an attempt can be made to maximize the turbocharger's rate of response. The use of turbocharger controls is a step in this direction.

Pressure Ratio Controls

Turbocharger controls are typified by the system diagram shown in Fig. 2. This device is used to maintain the output of the turbocharger compressor at a constant pressure ratio over a wide range of engine operating conditions. This is accomplished by measuring the actual compressor pressure ratio and using this signal to actuate a servo valve which regulates oil pressure (lubricating or fuel oil) to the bypass valve.

This bypass valve allows the exhaust either to go through the turbine or to bypass it, thus controlling turbine speed. The turbocharger is fitted with a nozzle whose area is much smaller than would be chosen for a free-floating turbocharger used with an engine of equivalent size and speed. This small nozzle keeps turbocharger speed at or near the desired maximum, regardless of altitude, throughout approximately the upper 50% of the engine speed and load range.

A control of this type eliminates to a large degree the time lag and smoke associated with accelerating the engine. This is important for vehicular and generating set applications. The control does some rather startling things to the engine torque and bsfc curves as well.

Fig. 3 compares the turbocharged diesel with and without pressure ratio control. Note that the torque rise is markedly increased through usage of the control. In actual service on trucks it has nearly halved the number of gear shifts on certain runs.

Torque ratio is not a function of input shaft speed. Torque converter input shaft torque is that developed by the engine. For a stalled converter, the input shaft torque speed resembles a propeller curve. The lugging torque curve of a highly turbocharged engine drops off severely at low speed. This drop-off varies with the degree of supercharge. At extremely low speeds this drop-off curve is not too far from being parallel to a propeller curve.

This characteristic has caused some startling field experiences with torque converter vehicles. These experiences have taken the form of a torque converter driving engine when loaded from low idle against a stalled converter. There have been instances where turbocharged engines matched closely to torque converters at sea level, but have at altitude been completely helpless, that is, they could not get up enough engine speed against the stalled converter to develop a reasonable output torque along the engine's torque droop line.

The converter, in turn, while maintaining a decent torque ratio, receives no torque from the engine at low speed. This results in a minute rim pull on the vehicle. Oppositely, there have been cases where by switching from one turbocharger to another, stalled torque converter engine speeds have increased markedly with obvious benefit to vehicle output.

Selection of the proper turbocharger coupled with use of the altitude-compensated pressure ratio control will go far toward alleviating the engine-torque converter matching variations which occur under varying altitude conditions. It will enable the engine torque output under low speed lugging conditions to stay above torque converter stall torque requirements until reasonable engine horsepower outputs are obtained.

Fuel consumption has been appreciably improved under part-load operation by providing sufficient excess air when using this control to give complete combustion even at part speed. Almost all conditions of operation show lower exhaust temperatures with the exception of maximum output which is relatively unaffected.

Intercooling

Another way of getting a more dense charge into the engine is to cool it (Fig. 4). This can be done

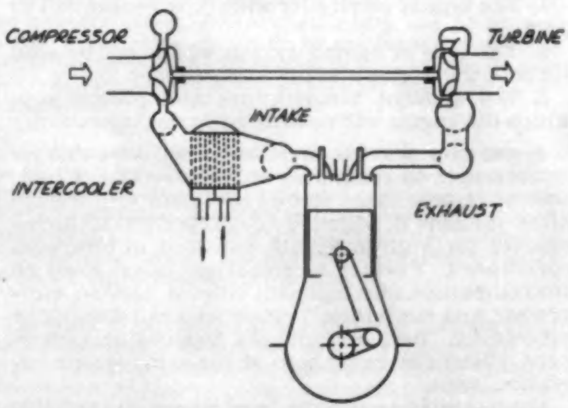


Fig. 4 — Turbocharger equipped with an intercooler.

with an intercooler, which cools the air leaving the turbocharger compressor. The heat sink may be jacket water, a separate cooling water system, or ambient air. The greater the temperature difference between the charge air and the coolant the better the intercooling. This means that jacket water, though convenient, is not the best heat sink from a performance standpoint.

Intercooling generally results in lower charge air temperatures and pressures for a given power and boost pressure level. This means lower exhaust temperatures and pressures, better internal cooling, lower firing pressures, and thus, lower engine mechanical and thermal stresses. On the other hand, it permits higher outputs for the same firing pressure and exhaust temperature (Fig. 5). Other helpful by-products are those of lower turbocharger speeds and temperatures, and hence longer life.

Fig. 6 gives some indication of the range requirements for a turbocharger compressor when operated in conjunction with various devices which tend to give the utmost in performance. Note that both intercooling and pressure ratio controls impose additional range requirements on the turbocharger compressor. If the compressor does not have the required broad operating characteristic, it will be forced to operate either too far to the left and in surge, or too far to the right and in regions of very poor efficiency.

Miscellaneous Factors

Various other factors affect the engine air consumption. One of these factors is valve timing.

Two turbochargers of different efficiencies can achieve the same air flow at the same density if provided with different engine valve timing. The tradition of high valve overlaps with turbocharged engines stems from inefficient turbochargers formerly available. However, an efficient turbocharger which produces large engine differentials so that the required air flow can be obtained with moderate valve overlap enjoys a transient response advantage over an inefficient turbocharger used with high valve overlap.

Deceleration transients are of no direct importance; accelerations are of importance since they take place either in response to or in anticipation of an increase in load. During acceleration transients, the power torque equilibrium equation for the turbocharger includes a large term for inertia acceleration torque. This additional torque required is supplied at the expense of engine scavenging during the transient; that is, during acceleration transients large unfavorable differentials exist across the engine.

An engine with a relatively low overlap valve timing can at least be filled as a positive displacement machine although the combustion gases in the chamber at the time of inlet valve opening can be expected to move into the inlet ports. An engine with high overlap will, however, undoubtedly reverse scavenge; that is, a substantial initial flow of any burned gas from the chamber and exhaust manifold will flow into the intake manifold at intake valve opening. The low overlap engine will have substantially more oxygen trapped in the combustion chamber than will the high overlap engine under these transient conditions. There is, therefore, a real advantage with efficient turbochargers because they can produce high differentials which allow the use of the tightest engine valving for a given air flow.

Consideration should be given to the expected extremes of ambient pressures and temperatures. An increase of ambient temperature tends to make the turbocharger run faster and flow a greater volume of air at higher pressures but at reduced density. This effect results in higher exhaust temperatures and a move of compressor flow requirements toward surge.

A decrease of ambient temperature also results in a faster running turbocharger, thus higher pressure ratios, and again moves the compressor requirement closer to surge. At the maximum power point, however, air weight flow also decreases because of poorer scavenge differentials and tends to lower compressor efficiencies resulting again in higher exhaust temperatures.

To Order Paper No. 71C . . .
. . . on which this article is based, turn to page 6.

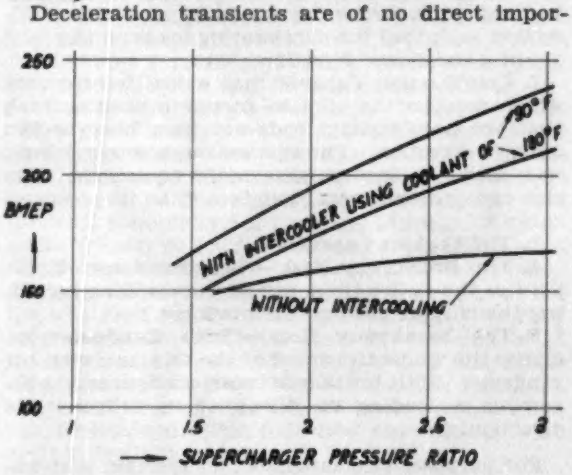


Fig. 5 — Typical bmep of turbocharged engine for constant exhaust temperature and constant firing pressure (with and without intercooling).

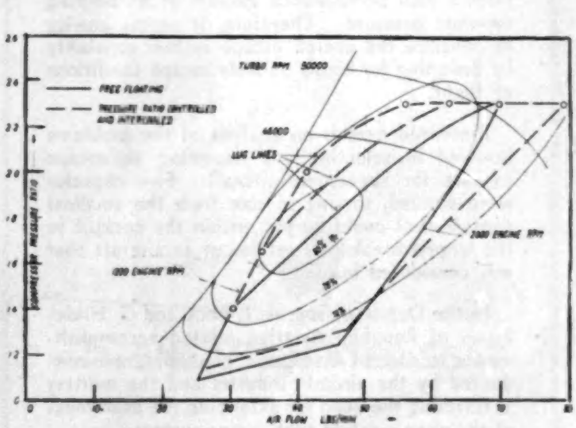


Fig. 6 — Effect of turbocharger controls and intercooling on the selection of a turbocharger.

Survival at low altitude should be major goal in . . .

Selection and Design of

THE average airspeed at time of pilot ejection has been lowering gradually in spite of increasing use of higher performance aircraft. Of the current supersonic aircraft, 87% of the ejections have occurred at indicated speeds of less than 400 knots. Eighty-four per cent of these occurred at less than 50% of the limiting Mach number of the aircraft. Over 42% of all ejections have taken place below 5000 ft, and at altitudes of 1000 ft and below, 72% of the ejections have resulted in fatalities.

This statistical evidence makes clear that if the escape system is designed for the maximum dynamic pressure conditions of flight, relatively few lives may be saved in the areas where very few, if any, escapes are made, while many lives will be jeopardized in the areas where many escapes are made.

As far as is known, no one has ever ejected from a high performance aircraft at its limiting dynamic pressure. Therefore, it seems unwise to penalize the overall escape system capability by designing for highly unlikely escape conditions of flight.

Presented here is an analysis of the problems involved in selecting and designing an escape capsule for supersonic aircraft. Five capsules were studied, varying in size from the smallest capsule that could be put within the cockpit to the largest breakaway section of an aircraft that was considered feasible.

In the October issue, A. I. Beck and G. Hildebrand of Republic Aviation related accomplishments to date of a veritable crash program conducted by the aircraft industry and the military in fulfilling the need for extending the usefulness of the open ejection seat escape system.

Based on paper by

Donald M. Root

Northrop Aircraft, Inc.

LOW-ALTITUDE capability is an important consideration in selection and design of an escape capsule for a supersonic aircraft. An analysis recently performed at Northrop shows why that's so.

Five capsules were chosen for this study because they included the four basic types derived from a survey of the literature and because they represent a step progression from the smallest capsule that could be put within the cockpit and from the smallest to the largest breakaway section of the aircraft that was considered feasible. These capsules are shown on page 47.

For the purposes of this analysis the five capsules are described as follows:

1. **Encapsulated Seat**: encloses the pilot only and is designed to be aerodynamically stable in a direction such that the decelerating loads on the pilot are in a transverse direction.

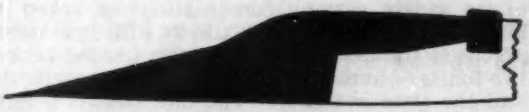
2. **Combination Capsule**: has a low frontal area which requires the pilot to assume a position such that the accelerating loads are in a head-to-feet positive direction. For this reason a lower *g* limit was used. It incorporates more equipment than the encapsulated seat, but less than the cockpit capsule.

3. **The Cockpit Capsule.**

4. **The Breakaway Nose — Less Randome**: incorporates the entire front end of the airplane including the cockpit but not the randome.

5. **The Breakaway Nose — With Randome**: includes the whole front end of the airplane with the randome. Both breakaway nose configurations assume a *g* loading on the pilot in a transverse direction.

For purposes of comparison, an ejection seat was included in the analysis. This seat rotates to a low frontal area position prior to the deceleration period, putting the pilot in such a position that the decelerating loads are in a feet-to-head direction



1. BREAKAWAY NOSE WITH RADOME

2. BREAKAWAY NOSE LESS RADOME

Escape Capsules

similar to the combination-type capsule. Some of the characteristics of the various configurations are shown in Table 1.

Conditions Basic to the Analysis

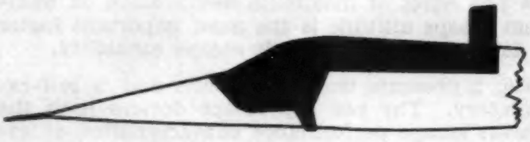
The drag coefficient of ribbon parabrakes behind large bluff bodies has been found experimentally to be approximately 55–60% of its subsonic value when the initial velocity of the system is supersonic. In deceleration flight, the drag coefficient increases continuously between Mach 1.2 and Mach 0.85 (see Fig. 1). If the parabrake is deployed at Mach 1.2 the subsonic drag coefficient should be used.

For performance conditions corresponding to a dynamic pressure (incompressible) of 2000 psf and due to the drag characteristics of ribbon parabrakes just noted, the critical conditions for parabrake selection are an initial dynamic pressure of 2000 psf at the time of rocket ignition and a Mach of 1.2 at the end of a delay time long enough to clear the vertical tail and deploy the parabrake.

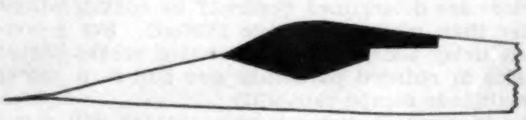
For all configurations studied it was assumed the main parachute would be a two-stage system (reefed and unreefed). Reefing of the main parachute provides low snatch or opening forces by reduction of the exposed drag area. It also prevents "false peaks" which would damage or destroy the parachute, reduce the decelerative shock on the pilot, and above all permits the main parachute to be deployed at the highest possible airspeed with the least possible loss of time and altitude. A transition velocity of 500 fps was considered low enough for the safe deployment of a large final-stage parachute in the reefed condition, and a velocity of 150 fps was used for the main parachute in the fully open condition. A steady-state rate of sink of 28 fps was used. Knowing the drag-weight characteristics and assuming a 90-deg vertical dive condition, the low-altitude capability of each configuration was determined. The following observations were derived from the analysis.

Observations Derived from Analysis

- There is a rapid increase in parabrake size permissible as the delay time to parabrake deployment



3. COCKPIT CAPSULE



4. COMBINATION CAPSULE

5. ENCAPSULATED SEAT

time is increased. This results from the decreased dynamic pressure at parabrake opening because of the longer capsule deceleration period.

- There is an optimum time delay for the encapsulated seat which will give the best low-altitude performance. However, the slight improvement in low-altitude capability is offset by a 40% increase in parabrake size. Capsules with a very high drag-to-weight ratio will be most likely to benefit from increased time delay.

- The minimum escape altitude has been shown to be almost completely independent of capsule weight, provided the parabrake size is varied to maintain the maximum deceleration at opening. However, an increase in weight without a corresponding increase in parabrake size is detrimental to the escape performance of the capsule.

- The effect of maximum g loading on parabrake size required is a linear function for all capsules and initial conditions.

- The effect of maximum deceleration on minimum escape altitude is the most important factor in determining low-altitude escape capability.

Fig. 2 presents the final results and is self-explanatory. The two $20g$ escape devices have the poorest escape performance characteristics, as expected. The relative performance of the capsules will remain the same for any other set of conditions, but the magnitude of the differences will change.

Other Variables Influencing Capability

Other variables affecting capsule low-altitude capability are rocket thrust, burning time, and airplane design dynamic pressure. However, these factors are determined generally by considerations other than minimum escape altitude. For a constant delay time, increased forward rocket thrust results in reduced parabrake size and in a poorer low-altitude escape capability.

An increase in dynamic pressure (q) will result in a decrease in parabrake size and in a poorer low-altitude escape capability. But this is true only up to a certain point. Above approximately 2134 psf and Mach 1.20, the parabrake will open at its lower supersonic drag coefficient, which means the airplane design q may be increased without affecting parabrake size. If the airplane design q is increased sufficiently, a supersonic parabrake opening at the higher q will be more critical than an opening at a q of 2134 psf and Mach 1.20, therefore, the parabrake size will again decrease with increasing q and low-altitude escape capability will be further compromised.

To regain some of the low-altitude capability lost at the higher dynamic pressures, multistage parabrakes will have to be used. But this will increase the complexity and no doubt will reduce the reliability of each capsule.

The Parachute Recovery System

The problem of safely decelerating and lowering an escape capsule by means of a parachute system centers mainly in the actuation and control devices needed to provide sequence of parachute operations under widely varying combinations of speed and altitude. These must gage and fit with split-second precision the deceleration impulse needed between two limits — human tolerance limits to acceleration and the time available. The one system designed for a sequence of several parachute operations at altitudes where ample time exists must also be capable of deploying the main parachute to maximum effectiveness in the shortest possible time at very low altitudes.

To provide an optimum recovery system under widely varying combinations of speed and altitude, some means of truncating or compressing the normal sequence of parachute operations is necessary. Two critical limits exist. Above the upper limit, only the parabrake may be deployed safely. Between upper and lower limits the main parachute may be deployed in the reefed condition. At and below the lower limit the main parachute may be deployed without reefing. This calls for a recovery-initiating-control capable of selecting the proper deployment mode automatically either prior to or immediately following ejection of the capsule.

Role of Ejection Devices

The need for a high degree of reliability suggests the desirability of independent parallel action rather than the common series arrangement, which depends on the brake parachute to deploy the main parachute. Moreover, the ground level capability of the system will be enhanced if the main parachute is ejected forcefully upward. Upward ejection reduces the total impulse required of the capsule ejection rocket when the minimum height required to effect parachute opening at low speed is a determining factor. It would be desirable also to bypass completely both the parabrake sequence and the reefing of the main parachute in order to achieve ground level capability at very low speeds. The parabrake drag could reduce the height of the capsule trajectory and, since parachute filling time is partially dependent on velocity, the drag of the parachute brake could cause a delay in inflation of the main parachute, especially at very low speed conditions. Elimination of the main parachute reefing sequence would cut down the time required to open fully the parachute.

Sequence of Operations

The problems associated with the integration of the actuator and control systems are best visualized by considering these various modes of operation required for a typical capsule:

The low altitude-medium speed and the low altitude-low speed sequence of operations are defined for flight conditions below the transition altitude of approximately 13,000 ft and include the ground level conditions of flight:

1. The pilot initiates ejection of the capsule.

2. Separation of the capsule from the aircraft triggers the parachute master ejection timer and activates the dynamic pressure sensor.

3. The dynamic pressure sensor selects one of

Table 1 — Comparative Characteristics of Five Capsule Configurations and an Ejection Seat

	Encapsulated Seat	Combination Capsule	Cockpit Capsule	Breakaway Nose, Less Radome	Breakaway Nose, with Radome	Ejection Seat
Ejected Weight (W), lb	584	878	1303	1904	2295	484
Drag Coefficient (C_D) at Mach 1.2	0.945	0.625	0.62	1.035	0.39	1.1
Max Frontal Area (S), sq ft	8	6	12.8	16.8	16.8	5
C_DS, sq ft	7.56	3.75	7.93	17.38	6.55	5.50
Deceleration Limits, G max	30	20	30	30	30	20

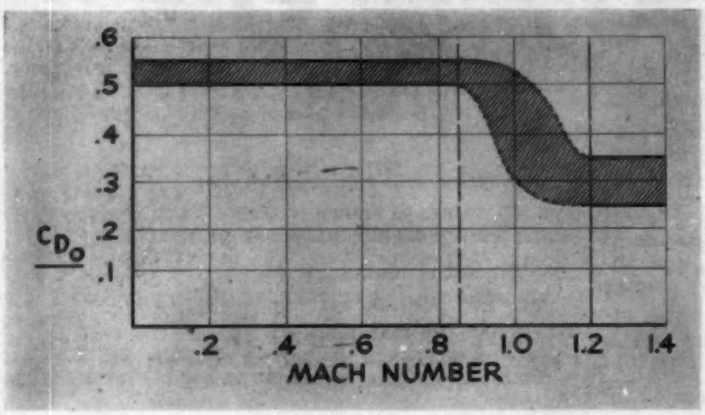


Fig. 1 — Change in drag coefficient with Mach number for a conical ribbon parachute.

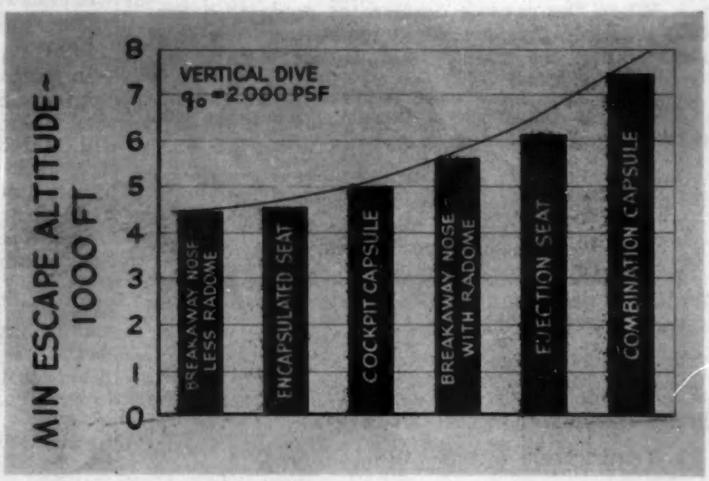
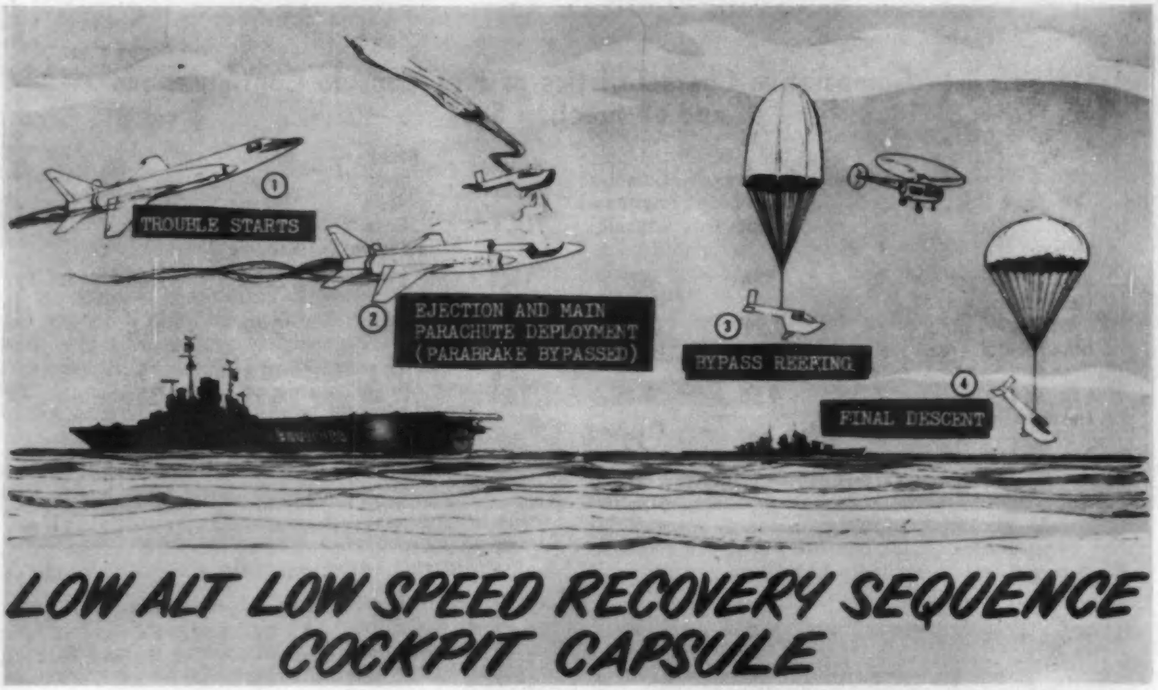


Fig. 2 — Minimum escape altitude for various capsule configurations. The ejection seat and combination capsule, the two 20g devices, are the poorest from an escape standpoint.



three deployment modes appropriate to the indicated airspeed as follows:

Low: The main parachute ejection circuit is armed, bypassing the parabrake entirely, and the reefing delay bypass device cuts the skirt reefing line prior to deployment.

Medium: Same as above except that the reefing line is not precut.

High: The parabrake ejection circuit is armed for the low altitude sequence.

4. After a short time delay the proper parachute is forcefully ejected.

5. When the capsule decelerates down to a certain dynamic pressure, the cutters sever the skirt reefing line; the main parachute opens fully, and stable descent follows.

6. At this point the automatic parachute disconnect must be armed.

7. Upon landing, the parachute is disconnected from the capsule.

Dynamic Pressure Limits

To determine the maximum dynamic pressure limits for each configuration studied, the following assumptions were made:

1. A stable system.

2. The deceleration loads will not exceed the limits shown in Table 1.

3. Temperature effects will be ignored.

4. Weights will remain constant.

5. C_D values as shown in Table 1 will remain constant for the higher Mach numbers.

Since the maximum $g = \frac{qC_DS}{W}$

Then the maximum $q = \frac{W_g}{C_DS}$.

Thus the limiting dynamic pressures (psf) are as follows:

Encapsulated Seat	2320
Combination Capsule	4680
Cockpit Capsule	4940
Breakaway Nose — Less Randome	3290
Breakaway Nose — With Randome	10,500
Ejection Seat	1725

In the foregoing assumptions, the parameters will change somewhat at the higher Mach numbers, so they are not altogether true. Fin sizes, for example, will increase with increasing Mach number, the structural weights will also increase because of the higher dynamic pressures and temperatures, and in some capsule configurations the drag coefficient will decrease with increasing Mach number. Therefore, the dynamic pressure limits shown, while not exactly true, will give some idea of the growth limitations for each configuration. The encapsulated seat is limited to approximately 2000 psf and the ejection seat cannot be used above 1725 psf, but all other configurations can be used above 3000 psf and so have considerably more growth potential.

To Order Paper No. 91D . . .
. . . on which this article is based, turn to page 6.

Russians Give "Full Speed Ahead" to Computer Projects

THIS REPORT on the Russian computer program came to the attention of Ralph E. Cross, Special Advisor to the SAE President on Computers. Cross considered the topic of interest to SAE members. For that reason he submitted it through President Creson with the recommendation that it be published in SAE Journal.

THE Soviet Union is placing great emphasis on the development of computers. Since 1956, they have been mass-producing three computers(Stella, M-2, and Ural) that are comparable to such computers as the IBM-704, Univac II, and IBM-650 or Datatron 205.

Among the computer projects either completed or in the works in the USSR are:

1. Development of an extremely large-capacity automatic dictionary.

2. Development of an automatic typesetter for printing shops.

3. Translation of one language into any other language.

4. Development of an automatic device for converting printed text into audible speech.

5. Development of special computer languages for individual areas of science.

A list of the characteristics of four digital computers in the Soviet Union is included in the table herewith. Unfortunately, much information is imprecise or unavailable, but those data given in the table are thought to be correct.

The "number trial" under "word-length" lists mantissa length, exponent length, and number of digits to the left of the radix point. The instruction pentad lists first address digit length, second address length, third address length, special-normalization or breakpoint digits, and operation digit length.

Table of Characteristics of Soviet Digital Computing Machines

	M-2	Ural	BESM	Strela
Builder	Energetics Institute of Academy of Sciences.	Scientific Research, Institute of, Ministry of Machine and Instrument Const.	Academy of Sciences, U. S. S. R.	
Date completed	1954	1955 "Quantity later"	1954?	1955 "Quantity later."
Pulse Rate	300-500 kc.	280 kc.		
Type	Binary, parallel 3-address floating Pt. Parallel storage.	Binary series-parallel single-address. Fixed point.	Binary Floating pt. parallel storage.	Binary.
Word Length	(28, 6, 0) (34, 0, 0)	(36, 0, 0)	(22, 5, 0)	(35, 6, 0).
Instruction	(10, 10, 10, 4)		(11, 11, 11, 1, 5)	(12, 12, 12, 1, 6).
No. of Insts	20	17		28.
Storage	512, 34-bit CRT. 512 Drum. 50,000 μ tape.	1024 Drum. 40,000 μ tape. 75 words/sec.	1023 39-bit CRT 296-word. Fixed diode store. 5120 Drum (750 rev./sec.). 4 x 30,000 mag. tape (400 words/sec.).	2048 43-bit CRT.
Indexing systems		Register as B-box.		
Registers	A, B, C, E.	Accumulator, "Register"		
Area		40 square meters	100-200 m².	100-200 m².
Input-Output	Paper tape 400 chars./sec. input on paper tape octal-decimal.	Perforated film 75 words/sec. input, 5 words/sec. output, octal-decimal.	Input punched tape 20 words/sec. Output-photoprinter 200 words/sec. Mechanical Printer 15 words/sec.	Punched tape, punched cards. Octal-decimal hexadecimal.
Applications	"Automatize the combined electric system of European USSR".	Scientific computations.	Scientific computations.	Scientific computations.
Operating Speeds	3,000 add/sec. goal—50,000/sec.	100 add./sec.	7,000-8,000 3-address ops/sec.	7,000-8,000 3-address ops/sec.
Circuitry	1,600 vacuum tubes, 3-tube plug-in.	800 tubes, 3,000 diodes	5,000 vacuum tubes. Plug-in packages.	
Automatic Programming	Subroutine Library on Magnetic tape.	Library of Subroutines "Compiling Program for Symbolic Form program".		Built-in Subroutines. Large-scale Compiler.
Publication Date of Source Document.	October 1956	October 1955		January 1956.
Similar Equipment	MIDAC SEAC	IBM-650 Datatron	IBM-704. ERA 1103 A.	IBM 704. 1103-A.

BAT and ABC . . .

BAT — Ballastable All-Purpose Tractor

Based on paper by

T. G. Timberlake, R. G. Alexander, N. P. Oglesby, and W. H. Leathers, Jr.

U.S. Army Engineer Research & Development Laboratories

BAT (Ballastable All-Purpose Tractor) and

ABC (All-Purpose Ballastable Crawler) are two new members of the Army's growing family of air-transportable construction equipment for use in assault-type operations. Engineering tests on the BAT are just about to begin; development of ABC was initiated under contract a few months ago. The logistical simplification to be realized with the application of these two new units is detailed in Fig. 1.

"Ballastable" Means . . .

The ballastable principle incorporated in both of these new vehicles was inaugurated to overcome operational shortcomings resulting from the 16,000-lb weight limitation imposed in 1949 on the family of air-transportable equipment.

With that weight limit, existing airborne construction equipment has not been capable of completing airhead and assault-type construction tasks within desired time limitations . . . nor does it have the necessary work potential. Application of the ballastable principle — which involves an air drop of a 16,000-lb vehicle with capabilities to ballast to 32,000 lb — provides twice the working capabilities of conventional construction equipment. Ballastable tractors from now on will incorporate the following:

1. Use of the most common material — dirt — as ballast.
2. Ability to self-load and self-unload the ballast.
3. Minimum use of critical materials.
4. Functional design, deleting unnecessary components and assemblies or gadgets.

BAT

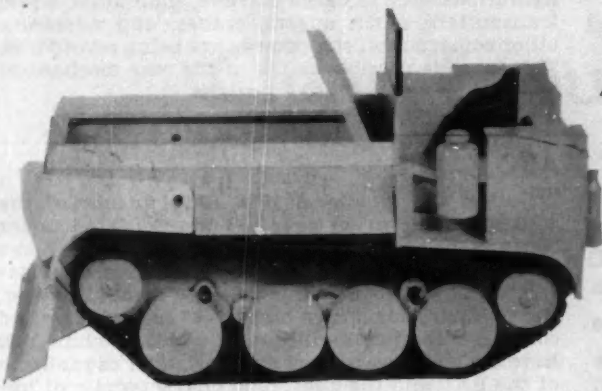
The BAT (shown above) will be ballastable to 32,000 lb and will be powered by a Lycoming 250-hp air-cooled gasoline engine. Rear-wheel drive of the unit will be by mechanical means. The front drive will be by a-c electrical assist, operable in the two lowest speeds. The rear drive train consists of the engine coupled to an a-c generator, then a clutch, a 2-speed auxiliary transmission, a transfer case, a 5-speed main transmission . . . and then into a final drive reduction which incorporates a torque-proportioning differential.

The unique BAT steering system is hydraulically controlled, with the dozer blade and push beams acting as the steering mechanism. This permits the wheels to follow in the path of the dozer cut on turns.

Since the push beams are mounted directly to the wheels and the king pin is mounted from the push beams to the front axle, only the force of the traction of the rear wheels is transmitted through the axle and king pins while dozing. This feature reduces the forces involved in the structural members concerned, permitting a substantial weight reduction. The front wheels may be leaned into a turn by raising the dozer blade above the center position, as the king pin rotates and the blade is raised or lowered.

The a-c electric assist system on the front wheels has been chosen because of its simplicity, its ability to synchronize the speed with that of the rear wheels regardless of engine speed, and its proved reliability. It is believed that the a-c assist will be required only

Members-to-be of Army's Airborne Family



ABC—ALL-Purpose Ballastable Crawler

for slow-speed operations such as dozing, scraper loading, and heavy drawbar loads. At higher speeds, engine power rather than traction is the limiting factor.

Other features involve the use of high-pressure hydraulics to conserve weight. The dozer blade and steering systems are operated at 6000 psi, whereas the ballast or scraper compartment is operated at 3000 psi. Engine, clutch, and transmission controls are remotely operated by either electrical or pneumatic means because the powerplant and drive train are located in the rear and the operator's compartment in the front.

Although this machine possesses most of the desired characteristics, it by no means is an ultimate design, particularly from the standpoint of individual components. It is anticipated that additional prototype units will be produced employing components tailored to the specific needs of the machine and at the same time exploit such aspects as capability to perform inland amphibious operations.

BAT, in the Army of tomorrow, will be capable of performing dozer, prime moving, and many other operations, having twice the work potential of present-day machines of the same size. It can be airdropped as well as transported by air. It can also be transported by heliborne means when the three basic sections (front, center, and rear operational

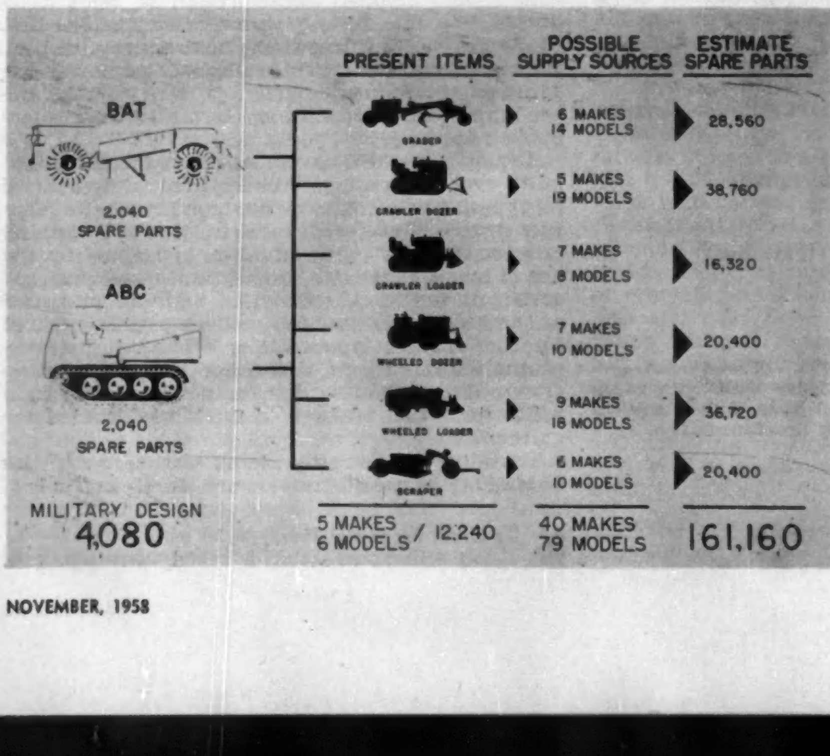


Fig. 1—Logistical simplification envisioned by completion of BAT and ABC, two new airborne construction vehicles.

Table 1 — Tentative Design and Performance Characteristics of BAT and ABC

	ABC Unit	BAT Unit
Weight (Air Drop), lb	16,000	16,000
Average Gross Weight, lb	35,000	32,000
Width, in.	100	100
Length, in.	192	300
Height, Air Drop, in.	80	81
Engine Horsepower	225	250
Normal Ground Clearance, in.	16	14
Ground Pressure, psi:		
16,000 Lb	6.1	—
32,000 Lb	12.5	—
Tire Size	[a]	1800 × 25
Tire Pressure, psi		25
Ground Contact Length, in.	98	
Bowl Capacity:		
Struck, cu yd	8	7.5
Volume, cu ft	216	202
Scraping Width, in.	100	96
Maximum Speed, mph	35	25
Minimum Speed, mph	1.5	1.5
Maximum Grade:		
Longitudinal, %	60	60
Side, %	60	35
Maximum Drawbar Pull, lb	26,000	20,800
Dozing Depth, in.	8	8
Maximum Turning Radius, ft	22	30
Angle of Approach, deg	30	25
Angle of Departure, deg	Unlimited	25
Flotation or Soil Trafficability		
Vehicle Cone Index, Empty	45[b]	42[b]
Vehicle Cone Index, Loaded	68[c]	53[d]

[a] Newly developed high-speed track and suspension system featuring lightweight alloy, rubber bushed single pin center guide with large diameter road wheels without track carrier rollers. Suspension is hydropneumatic.

[b] Second category vehicles.

[c] Fourth category vehicles.

[d] Third category vehicles.

components) are detached and handled as individual loads. One other feature of the BAT to be exploited in future development concerns the capability to detach the front and rear operational components easily and insert a variety of body configurations between these components. Body configurations such as cargo carriers, shop units, liquid transporters, earth augers, cranes, and numerous other construction equipments are being considered. This is made possible by use of the rear mechanical and front electrical-drive systems.

ABC

During the middle of 1958, development of the ABC unit (shown on page 53) was initiated under contract to the International Harvester Co. Some of the concepts employed in the early phases of development of this machine are now firm. However, the configuration shown on page 53 has been revised considerably since its inception. This machine will have all the construction and logistical capabilities of the BAT and the additional characteristic of improved mobility. The ballast compartment of this unit is front loading; therefore, it may also be used to transport pod-type loads, such as shop units, servicing and utility equipments, and pioneer construction equipments. These pod loads would also be capable of being transported by heliborne means. The ABC tractor can self-load or self-unload palletized cargo by means of the ballast ejector.

To make this ABC vehicle feasible, it is necessary to develop a track suspension system capable of satisfactory high-speed transport operation as well as low-speed dozing and scraping operations, requiring a combination suspension system, which is flexible at high speeds and rigid at low speeds. One other key design consideration involves use of a scraper cut equal to outside track width for the ballast compartment in order to provide a uniform cut and better grading capabilities; and to construct slot-type excavations. Because conventional scrapers have vertical bowl walls, extensive investigation of proper ballast compartment configuration is being conducted. To date, tests have indicated that the best configuration for the bowl will be to use a ramp over the track assemblies. This ramp will employ a conventional dozer blade-cutting angle, whereas the center section will utilize a conventional scraper-cutting angle.

Although the ABC tractor will have increased mobility over conventional rubber-tired equipment of all types, it will not have the mobility of the large wide-track, slow-speed, present-day earthmoving crawler tractors. This situation is created by the use of a less aggressive grouser and lesser bridging action of the track. Flotation (ground pressure) of the unballasted unit is excellent when compared to other tracked-type vehicles. However, flotation of the ballasted unit is inferior to some existing crawler-type vehicles. This is created by the rigid width limitation imposed to meet the airborne requirement.

Tentative design and performance characteristics of the BAT and ABC tractors are shown in Table 1.

To Order Paper No. 75B . . .
. . . on which this article is based, turn to page 6.

Keeping Fuel Clean Enough for Turbines

requires careful handling and testing all the way from refinery to airplane tank.

Excerpts from paper by
C. E. Loeser, Esso Research & Engineering Co.,
D. D. Love and A. R. Ogston, Esso Export Corp.

FUEL dispensed to modern turbine aircraft requires a quality of cleanliness and freedom from entrained water of a degree never contemplated when considering piston engined aircraft.

This requirement is partly a matter of safety because dirty or wet fuel can cause engine failures. It is also a matter of economics. Turbine aircraft use relatively large amounts of fuel, and thus the fuel feed and pumping systems are required to work relatively much harder in any given operating life. Therefore, these parts are more sensitive to factors affecting their life than were similar systems in piston engines.

In addition, the clearances of pumps and fuel control mechanisms are small, the fuel pressures are very much higher, and the sensitivity to micronic size particles of solid contaminant is consequently greatly increased.

Turbine-powered aircraft are generally more expensive to operate on an hourly basis than piston-engined aircraft. Although the potential revenue is greater because of the higher payload and relatively faster flight, the ground time of an aircraft necessitated by servicing or a mechanical delay can be very costly.

The fuel used by turbine engines, whether it be kerosene or JP-4, is by its nature liable to carry fine particles of rust, water, or other foreign material in suspension to a much greater extent than is the case with gasoline. Kerosene and JP-4 also tend to dislodge existing rust and scale from the interior surface of tankers, pipelines, storage tanks and other handling equipment to a greater extent than is experienced with gasoline. This is explained by certain differences in the physical properties of the two fuels—that is, the greater viscosity and heavier density of kerosene as compared with aviation gasoline. Because of these two factors, finely divided rust and small particles of water can take from five to ten times as long to settle in kerosene as they do in gasoline.

If turbine-engined aircraft require ultra clean fuel to secure optimum life, how clean should that fuel be? This is a question that as yet has no scientifically accurate answer, although educated guesses have been made.

How to Keep Fuel Clean

The overall concept which has emerged from studies of the handling of turbine fuel is that the cleaning and drying of the fuel is a progressive task and must receive due emphasis at all stages of handling. Close to "nozzle quality" must be obtained as the product leaves final storage.

Whenever possible, and to the greatest extent practicable, these principles should be followed:

1. Let nature — that is the force of gravity — perform its share of the work in removing water and solid contaminants from fuel. In other words, allow adequate settling time in storage tanks. Not all natural laws are beneficial to settling time. Other phenomena, such as convection currents, can hinder the effective settling out of contaminants. Any system must be designed to derive the optimum benefit from settling time, allowing for all factors.
2. Prevent the entrance of dirt and water from external sources into the fuel by suitable procedures and by the use of suitable equipment from refinery storage to aircraft.
3. Use mechanical devices for removal of dirt and water with increasing frequency and increasing mechanical effectiveness as the product approaches its ultimate destination, the aircraft. The mechanical devices should be considered principally as a means of providing additional assurance of product dryness and cleanliness rather than as devices upon which complete reliance can be placed. They are supplementing the forces of nature, especially with regard to the removal of solid contaminants and water droplets of small dimensions.

Considering an airport refueling system, the following is a summary of currently recommended practice:

1. The fuel is passed through a filter-separator into airport storage. This filter-separator must at

least meet U. S. Government Specification MIL-F-8508A.

2. In storage, the principle of allowing settling time must be insured. Wherever practicable, more than one tank is provided in order to isolate completely the tank containing product that is being settled.

3. After leaving storage the fuel is passed through a filter-separator meeting U. S. Government specification MIL-F-8508A. (This is a minimum requirement. In order to exercise additional control, it may be necessary to install an additional filter in series.) By suitable manifolding and valves, this filter-separator could be the same one as is used upstream of storage if the throughput and nature of operations permit such an arrangement.

4. If the installation is not a hydrant system, every care should be exercised in loading the mobile refuelers to exclude airborne dust and dirt, rain water, and other foreign material. One method of achieving this protection is to use a tight-fill connection. The fittings required for this are under active development now.

5. The tanks on the mobile refueler should be constructed either of stainless steel, non-ferrous material, or steel coated with an approved and reliable inert material. It is also desirable to use these materials for the piping on refuelers and on hydrant system servicers. This will minimize contamination of the fuel from these sources.

6. On the vehicle (mobile refueler or servicer) there should be a filter-separator, equipped in some way not only to separate any accidentally acquired water from the fuel, but also to bar the passage of the coalesced water through the equipment. It is desirable that such filtration equipment should have a specified micronic size cut-off for dirt particles.

7. All the usual safety and quality control practices and procedures should be followed throughout. Frequent quality checks such as the "clear and bright" test should be utilized. Continual emphasis must be laid on cleanliness of the product when training refueling personnel. (For example, "Don't let the nozzle drag on the apron — pick it up," or "keep the dust cap on the nozzle at all times when not engaged in refueling.") The training and retraining of personnel is an extremely important factor in insuring that the policies and requirements of both the fuel supplier and the customer are being followed.

The filling of mobile refuelers through a tight-fill connection excludes dirt and water from external sources at a critical point in the handling system.

There are several different pieces of equipment commercially available with which a tight-fill system can be built. In addition to these, an "Audio Vent Alarm" system is being developed by the authors' organization. This in corporates the installation of two discordant whistles that indicate to the operator when the tank truck compartment is nearly full, and then when it is full. It would be desirable that the filter-separator provide a guaranteed absolute cut-off in the maximum micronic size of particle it will allow to pass.

There are probably several routes which could be followed in developing an absolute cut-off device:

1. A very fine metal screen.
2. Some kind of biological filter element.
3. A sintered metal element.
4. A combination of two or more of the above.

Probably there are other materials which would be equally suitable. However, absolute cut-off should be provided by virtue of pore size. The cut-off device should be free of filtration duties other than limiting the maximum size of particle which can pass through.

The absolute cut-off device, having by nature a low dirt holding capacity, will soon plug up if any failure has occurred upstream. By reading a pressure gage, or even by observation of greatly reduced flow rates, the operator of the refueling equipment will know that all is not well with the system and can take immediate steps to trace the sources of the trouble and institute corrective action.

It is essential to have some sort of tool that will indicate whether the control features are working properly and what order of magnitude of cleanliness the fuel has as it is being delivered.

Several devices have been developed to indicate the presence of free water in fuel. These are spot check devices, used for example to check the water content of the fuel in a refueling truck before each delivery. The accuracy and reliability of these devices could and should be substantially improved.

Method for Measuring Contaminants

For the measurement of solid contaminants, a sampling kit has been developed and is being used in Canada which is comprised of a sampling valve and its adaptor, cap, and wrench; a sampling bomb assembly; a graduated polyethylene jug (filtered sample); a plain polyethylene jug (flush bottle); and a millipore field monitor of Type MAWP-037-Tenite.

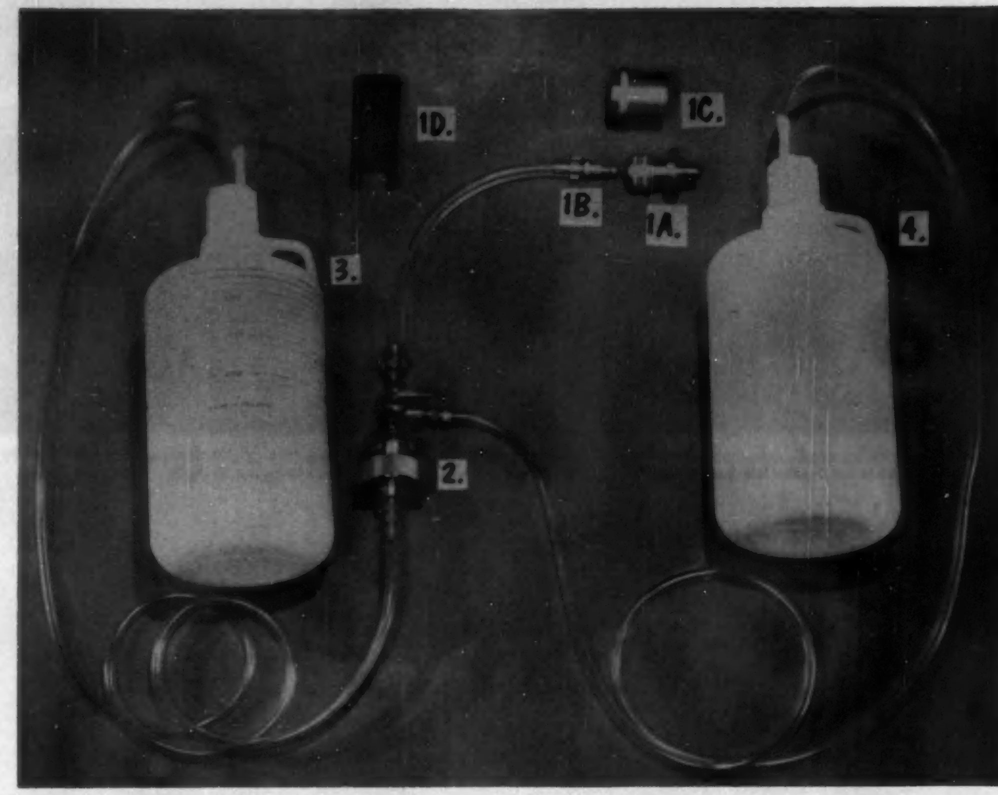
The Millipore membrane in this type of monitor has an absolute cut-off size of 0.8 microns. The Millipore membrane also has the property of retaining solid particles on its surface, without penetration. Therefore, a particle count can be carried out, if desired, as well as a weight measurement.

Briefly, the object of the exercise is to take a 1-gal. sample of fuel at the hose nozzle during the course of the refueling operation. The fuel sample is filtered through a pre-tapered Millipore filter membrane, which is subsequently weighed in the same laboratory in which the tare weight was obtained. The difference between tare weight and subsequent gross weight gives a measure of the contaminant in the fuel and can be stated on a weight per gallon basis.

The laboratory procedure used is in the process of being standardized under the American Society for Testing Materials. The procedure was developed by Esso Research and Engineering Co., Imperial Ltd., and Shell Oil Co.

The frequency with which samples are taken is a matter of judgment, dependent upon throughput, average size of refuelings, and number of refuelings in any given period of time.

This type of sampling can be done at any point in



BOMB SAMPLING KIT includes sampling valve (1A), Tygon pressure tube and adaptor (1B), cap to protect sampling valve when it is not in use (1C), pin wrench for sampling valve maintenance (1D), sampling bomb (2), a graduated polyethylene jug (3), and a plain 1-gal polyethylene jug.

The sampling valve screws into the threaded boss on the side of the Buckeye underwing refuelling nozzle. Before sampling, the bomb is loaded with a Millipore Field Monitor type MAWP 037 tenite filter cartridge. The filter disc inside the cartridge is weighed before and after sampling to determine the weight of the deposit removed from the measured sample.

the system, if desired, providing proper sampling valves are installed. Thus, the introduction or removal of solid contaminant at any point in a given system can be studied.

There are some disadvantages to sampling with the bomb. The chief one is that this is a spot check only.

To overcome this disadvantage, what is called an "averaging sampler" is being developed. This is similar to the bomb sampler in that some of the fuel is fed through a Millipore filter membrane. The difference is that the averaging sampler is permanently installed on the refueling vehicle and takes a sample for the duration of each refueling. The Millipore monitor, however, is not changed at each refueling. The equipment samples the fuel over a number of refueling operations, at a controlled flow rate and with a careful measurement of the total quantity of fuel passing through the sampler. When the Millipore membrane is weighed, what is obtained is, in effect, an average level of cleanliness of the fuel.

Once again the frequency of changing of the Millipore monitor is a matter of judgment, depending upon throughput in any given period of time, and also the quantity of information that may be desired for other reasons.

Measuring the quantity of fuel passing through the sampler has been a problem due to the extremely low flow rate. No simple method has been developed as yet.

The averaging sampler could also be used to measure the performance of equipment such as a filter-separator. By measuring the actual performance of filter-separators, more realistic maintenance schedules for the changing of elements can be set up. Performance data would be used to augment the somewhat arbitrary figures of pressure drop, throughput, or elapsed time currently used.

Research has been directed toward the development of electronic dirt detectors, but to our knowledge, none are practical as yet for use on mobile equipment.

To Order Paper No. 89C . . .
. . . on which this article is based, turn to page 6.

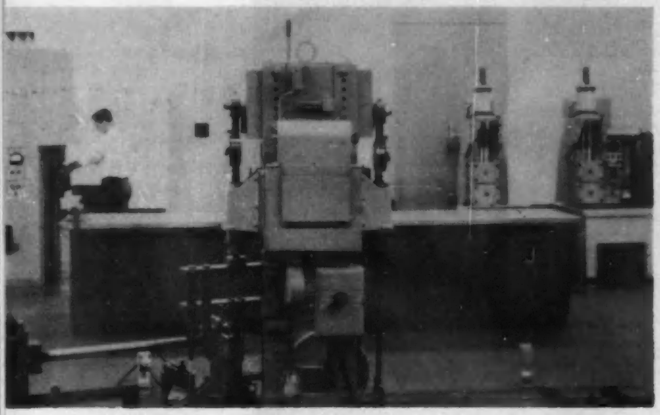


Fig. 1 — Hydraulic strokers (right background) are more powerful and versatile than even the newest mechanical types (left background).

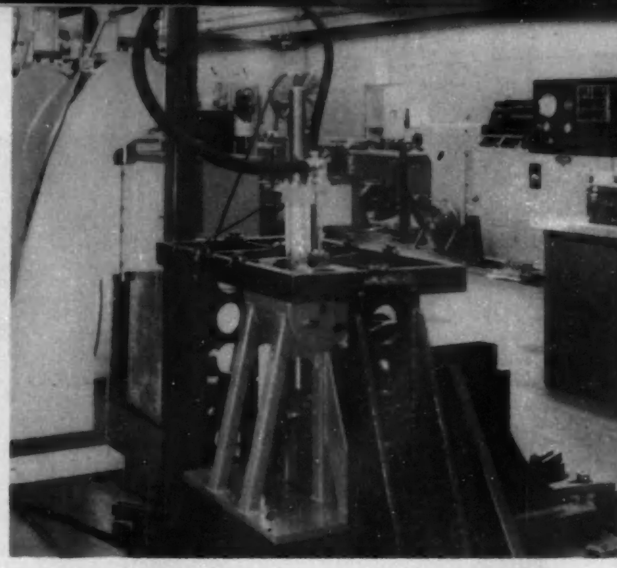


Fig. 2 — Front suspension being checked for dynamic rate with new hydraulic stroker, capable of amplitudes up to 10 in.

NEWEST Chevrolet

Based on paper by

Max M. Roensch and Nelson E. Farley

Chevrolet Motor Division, GMC

STILL NEWER experimental methods are under development in Chevrolet's new engineering laboratory, despite the fact that this recently equipped motor vehicle testing center has just been fitted out with the latest devices and procedures.

Among these newest developments:

- New hydraulic strokers.
- A new rotary fatigue machine.
- A newly designed impact pendulum.
- New-type electronic programmers.
- A new 600-hp dynamometer.

New Hydraulic Strokers

The new hydraulic strokers have already been designed and are undergoing trial runs. These machines are more powerful and more versatile than mechanical strokers.

The new hydraulic strokers (shown in the right background of Fig. 1) are more powerful and more versatile than even the newest type mechanical strokers (shown in the left background). In the foreground of Fig. 1 is an older mechanical stroker.

These two new hydraulic machines are powered by separately installed oil pumps and are capable of amplitudes up to 10 in., force up to 25,000 lb, and frequencies to 1200 cpm.

Displacement can be made to vary over almost any stroke-time pattern, such as sinusoidal, triangular, or square wave. Each pump for a hydraulic stroker is driven by a 60-hp motor and can produce 39 gpm flow at 3000 psi. The cylinders may be separately mounted for special test requirements. Fig. 2 shows a front suspension being checked for dynamic rate.

New Rotary Fatique Machine

The new rotary fatigue machine (Fig. 3) produces loads of 15,000 lb-ft on the spindle, and gives rotational speeds of 60–210 rpm. This machine tests wheels, hubs, drums, and shafts by applying bending loads on them while they rotate, thus simulating heavy vehicle cornering loads.

Incipient failure is detected by a deflection-sensitive circuit at the loaded end of the spindle. Pneumatic loading does away with the cumbersome weights used on earlier rotary fatigue machines.

New Impact Pendulum

The newly designed impact pendulum (shown in Fig. 4) is a 3500-lb weight on a 12-ft arm which is remotely released. It can simulate any desired collision energy on bumpers and bumper supports, which are mounted on a dummy vehicle that rolls with the impact. Interchangeable impact bars on the weight permit simulation of collision with any object such as a post, wall, or other bumper. Test

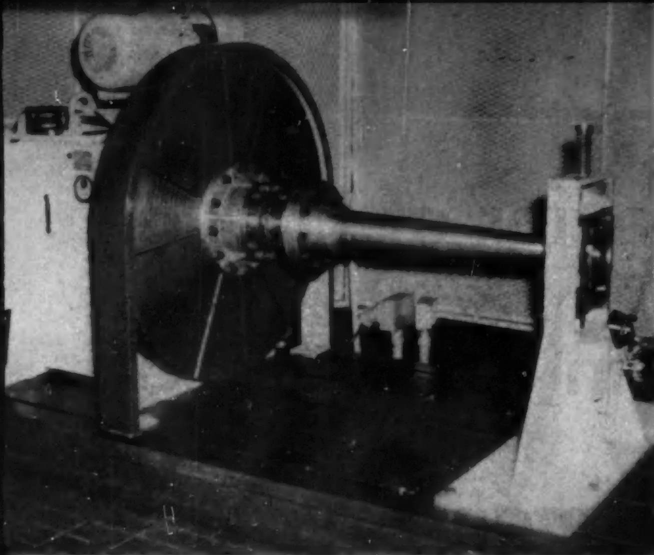


Fig. 3 — New rotary fatigue machine which produces 15,000 lb-ft on the spindle, gives rotation speeds of 60-210 rpm.

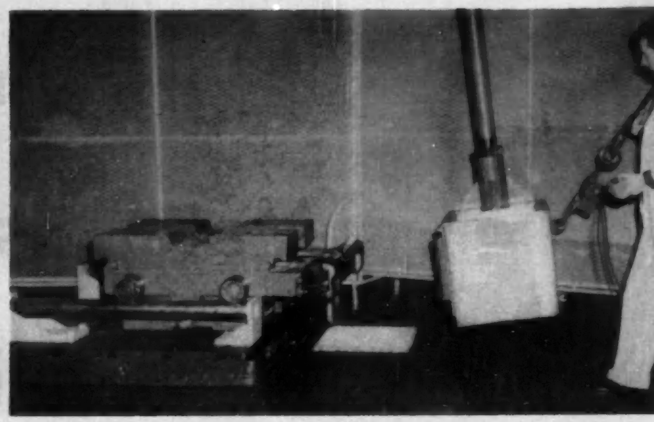


Fig. 4 — Newly designed impact pendulum has 3500-lb weight.

Lab Methods

results provide precise data to aid future design components.

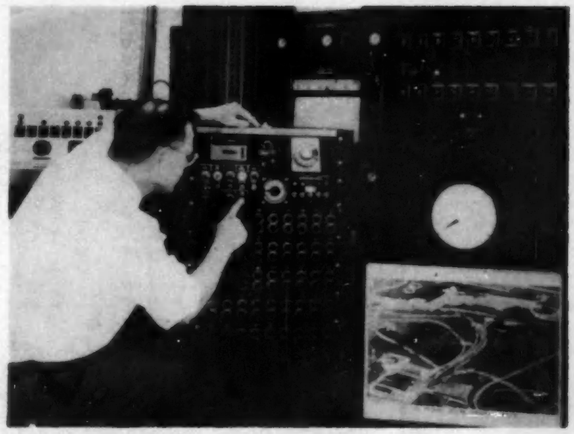


Fig. 5 — New electronic programmer for dynamometer control circuit.

Electronic Programmers

Electronic programmers are being designed to permit automatic, perfectly repeatable cycling of engines or transmissions through a variety of conditions.

The programmer in Fig. 5 is used in the control circuit of a dynamometer. It puts the transmission on test through every condition of load, speed, and control linkage position, thus reproducing the exact proving-ground test schedule. Such programming will undoubtedly come into much greater laboratory use in the near future.

New 600-hp Dynamometer

A new 600-hp dynamometer (Fig. 6) is capable of 8000 rpm and 1950 lb-ft torque. It provides for power development at high engine speeds. This machine also permits investigation of valve-train operation and other critical components at speeds higher than they will attain in customer service.

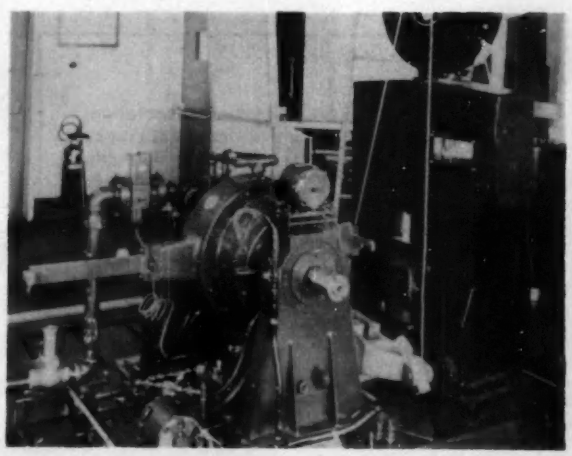


Fig. 6 — New 600-hp dynamometer for power development at high engine speeds, capable of 8000 rpm and 1950 lb-ft torque.

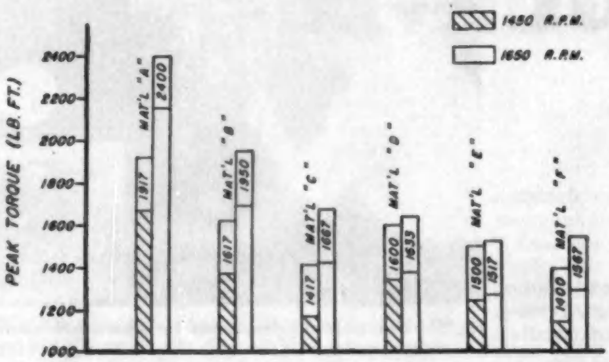
Other Developments

Other trends point to the increased use of computers to aid in highly complex studies, possible use of radioactive materials for wear and tracer tests, and wider application of electronic instrumentation.

To Order Paper No. 72F . . .
. . . on which this article is based, turn to page 6.

Behavior of Friction Materials in Construction Equipment Clutches

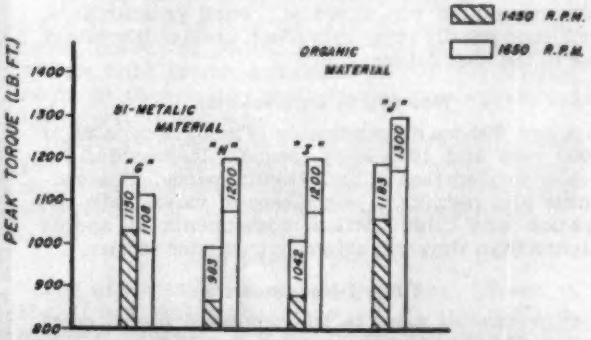
Based on paper by
J. R. Prosek and H. M. Barber
International Harvester Co.



RELATIVE TORQUE characteristics of ceramic materials on snap engagement of a 13-in. single-plate, over-center clutch at engine speeds of 1450 and 1650 rpm. This class of friction materials offers a wide range of values. In early tests two different horsepower settings were used, but on evaluating the data it was found that peak torques were primarily a function of the WR^2 of the engine rather than horsepower. From then on, throttle settings were changed to speed tests.

THROUGH comprehensive studies, International Harvester has developed significant data on the relative behavior of certain ceramic, bimetallic, and organic friction materials in engine clutch applications, as well as data on the peak torque values obtained during clutch engagement.

The charts and captions on these pages tell the story of these test findings, which should provide background data for clutch applications.



RELATIVE TORQUE characteristics of representative bimetallic and organic friction materials under conditions identical with those shown in the previous chart. Comparison shows these materials in general give peak torque values well below those of the ceramic type. Both charts represent tests made with a crawler tractor.

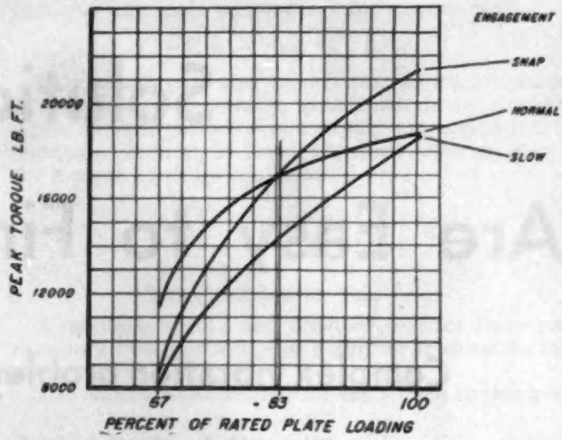
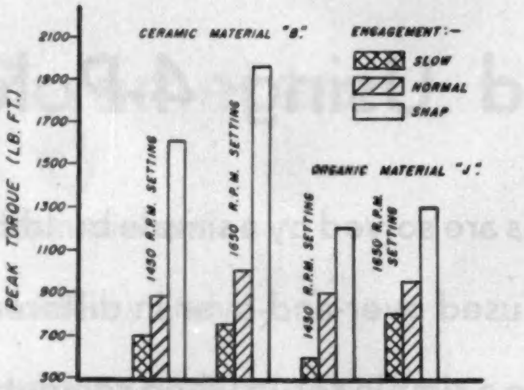
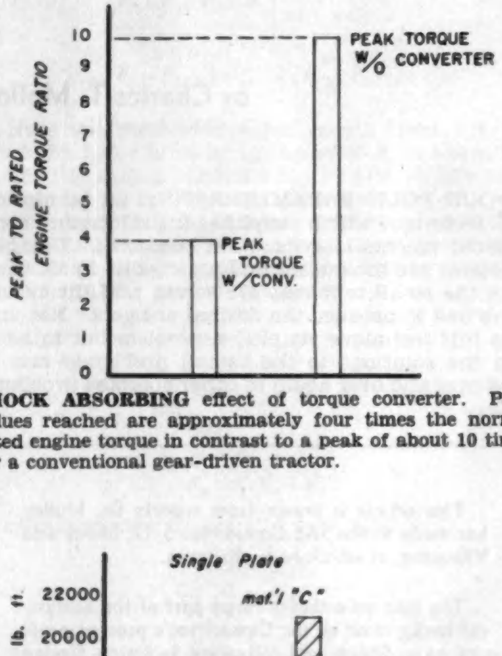


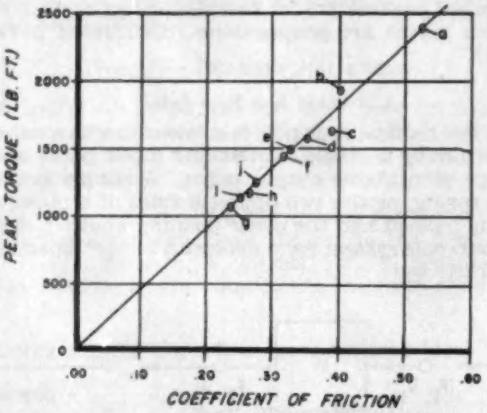
PLATE LOADING EFFECT on peak torque values of a typical 17-in. single, spring-loaded clutch.



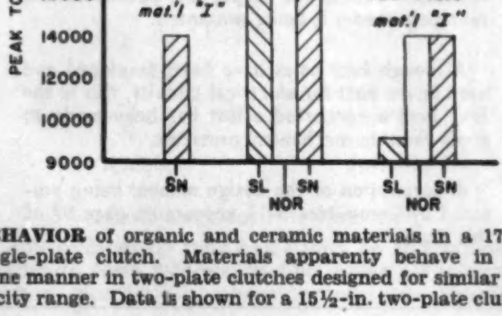
CLUTCH ENGAGEMENT has considerable bearing on the shock loads imposed on the components of a machine, but specific data have been lacking. Here are shown the differences in peak torque values obtained with snap, normal, and slow engagement of a 13-in. single-plate, over-center clutch. The results also reflect to some extent the effect of heat buildup on the torque characteristics of organic materials as compared to the ceramic type.



SHOCK ABSORBING effect of torque converter. Peak values reached are approximately four times the normal rated engine torque in contrast to a peak of about 10 times for a conventional gear-driven tractor.



PEAK TORQUE values versus coefficient of friction with a 13-in. single-plate, over-center clutch. This knowledge of materials coupled with field performance data makes possible determining within narrow range what the coefficient of friction must be for a given application.



BEHAVIOR of organic and ceramic materials in a 17-in. single-plate clutch. Materials apparenty behave in the same manner in two-plate clutches designed for similar capacity range. Data is shown for a 15½-in. two-plate clutch.

To Order Paper No. 76A . . .
. . . on which this article is based, turn to page 6.

Solutions to Vibration Are Easy to Find Using 4-Pole

Complex vibration problems are solved by a simple building The "blocks" can be used over-and-over in different lend themselves to a simple setup when computer

by Charles T. Molloy
Lockheed Aircraft Co.

"FOUR-POLE PARAMETERS" is an analytical technique which simplifies the solution of complicated mechanical vibration problems. Complex problems are broken up into a series of small ones; then the small problems are solved and the results combined to produce the desired answers. Not only does this technique simplify a problem but in addition the solutions to the "small problems" can be used over and over again in other complex problems.

This article is drawn from reports Dr. Molloy has made to the SAE Committee S-12, Shock and Vibration, of which he is chairman.

The four-pole theory forms part of the analytical background of the Committee's present project on a Shock and Vibration Isolation Design Manual. Since the manual will give a step-by-step procedure rather than an explanation of the technique behind the steps, this outline of the four-pole theory is being presented.

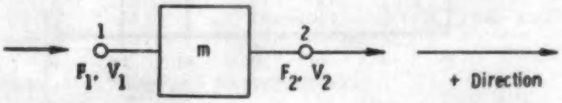
Although four poles have been developed and used in the past for electrical circuits, this is the first time a concerted effort has been made to apply them to mechanical problems.

A description of the design manual being prepared by Committee S-12 appears on page 97 of this issue.

The range of mechanical problems that yield to four-pole analysis includes all linear systems and in the future it may be possible to extend the theory to some non-linear cases. Obvious applications are to systems with unidirectional motion but other situations, such as six-degree-of-freedom systems are readily handled. The four-pole technique can be applied to lumped and distributed systems, for example: spring, mass, and dashpot combinations (lumped parameter), or helical springs or beams on which waves are propagating (distributed parameter).

What Is a Four Pole?

A mechanical four pole is a linear mechanical system having a single identifiable input point and a single identifiable output point. A simple example is a spring, or the two opposite sides of a mass, one being pushed and the other pushing another object. A four-pole system for a mass can be identified symbolically by:



where:

m = Mass

F_1 and F_2 = Input and output forces, respectively

V_1 and V_2 = Input and output velocities, respectively

The name four-pole parameters comes from the four coefficients α_{11}, α_{12}, α_{21}, and α_{22}, in the pair of

Problems

Parameters

block technique.

problems and

analysis is used.

equations that will completely describe the mechanical system. These equations are:

$$\begin{aligned} F_1 &= a_{11}\ F_2 + a_{12}\ V_2 \\ V_1 &= a_{21}\ F_2 + a_{22}\ V_2 \end{aligned} \qquad \text{Eq. (1)}$$

These equations can be used to describe a system no matter what has happened to the left (input) or will happen to the right (output). This is why the solution of a small part of a system can be re-used in another problem.

Four-Pole Parameters for a Mass

A useful set of parameters are those for a mass experiencing sinusoidal motion. To find the four poles, three steps are taken in this or other examples. They are:

(1) Write the equations of motion for the system.
(2) Solve the equations subject to the boundary conditions: F_1, V_1 (input); F_2, V_2 (output).
(3) Rearrange the equation to the form shown in Eq. (1).

Doing this for a mass we have for step (1):

$$V_1 = V_2$$
$$F_1 - F_2 = m\,dV_1/dt = m\,dV_2/dt$$
$$F_1 = F_{10} \cdot e^{i\omega t}$$
$$F_2 = F_{20} \cdot e^{i\omega t}$$
$$V_1 = V_{10} \cdot e^{i\omega t}$$
$$V_2 = V_{20} \cdot e^{i\omega t}$$

where F_{10}, F_{20}, V_{10}, and V_{20} are complex numbers that are independent of time. The usual conventions are used in representing sinusoids by complex exponentials.

Solving the equations and rearranging into standard form gives:

$$F_1 = F_2 + (m\omega i)\ V_2$$
$$V_1 = 0 \cdot F_2 + V_2$$

and the four-pole parameters for a mass are:

$$a_{11} = 1,\ a_{12} = m\omega i,\ a_{21} = 0,\ a_{22} = 1$$

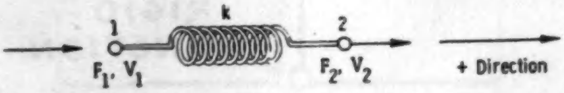
This result can also be written in matrix form. Although not necessary, this form is convenient when several mechanical systems are combined in tandem. In matrix form, the four-pole equations for a mass in sinusoidal motion are:

$$\begin{bmatrix} F_1 \\ V_1 \end{bmatrix} = \begin{bmatrix} 1 & m\omega i \\ 0 & 1 \end{bmatrix} \begin{bmatrix} F_2 \\ V_2 \end{bmatrix}$$

Spring and Resistor Four Poles

A massless spring and dashpot resistor have parameters that are found in a similar manner to the mass.

The equations of motion for the spring shown are:



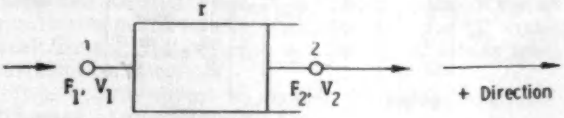
$$F_1 = F_2;\ F_1 = R\left[\frac{V_1}{\omega i} - \frac{V_2}{\omega i}\right]$$

or:

$$F_1 = F_2 + 0 \cdot V_2;\ V_1 = \frac{\omega i}{R} F_2 + V_2$$

Here the second equation comes from the fact that the force is equal to the stretch in the spring times the spring constant k. V_1 and V_2 are again sinusoidal, as in the case of the mass.

The dashpot is classically assumed to have a resistive force equal to a constant times the relative velocity of the pot and plunger. The equations of motion for the case shown are:



$$F_1 = F_2$$
$$F_1 = r\,(V_1 - V_2)$$

and rearranging in the standard form:

$$F_1 = F_2 + 0 \cdot V_2$$
$$V_1 = \frac{1}{r} F_2 + V_2$$

The four poles for these two cases along with the corresponding matrix is:

spring	resistor
$a_{11} = 1, a_{12} = 0$	$a_{11} = 1, a_{12} = 0,$
$a_{21} = \frac{\omega i}{R}, a_{22} = 1$	$a_{21} = 1/r, a_{22} = 1$
$\begin{bmatrix} 1 & 0 \\ \frac{\omega i}{R} & 1 \end{bmatrix}$	$\begin{bmatrix} 1 & 0 \\ 1/r & 1 \end{bmatrix}$

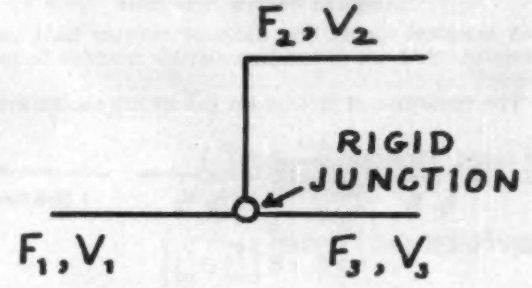
Combining Four-Pole Parameters

Any number of four poles may be connected together to form systems of four poles. The performance equations of these systems are found by

using (1) equations of constraint and (2) the four-poles equations of the individual components.

The equations of constraint say that the forces on both sides of a rigid joint must be equal and that the velocities of all points connected to the joint are equal. If the joint were a hydraulic one, the equations of constraint would be different, but equally simple.

An example of three components being connected is shown below. F_1, V_1 is the output of a component on the left of the junction and F_2, V_2, F_3, V_3, are the inputs to two components on the right.



The equations of constraint are:

$$F_1 = F_2 + F_3$$
$$V_1 = V_2 = V_3$$

Two special cases of this combining principle are the tandem and parallel connection of four poles.

In the tandem case the matrix for each component is multiplied by the other matrices. Care must be taken that the matrices are in the same order as the physical arrangement of the components. An example of the matrix of a spring and mass in tandem is:

$$\begin{bmatrix} 1 \cdot 0 \\ \frac{\omega i}{R} & 1 \end{bmatrix} \times \begin{bmatrix} 1 & m\omega i \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & m\omega i \\ \frac{\omega i}{R} & 1 - \frac{m\omega^2}{R} \end{bmatrix}$$

spring × mass =
spring and mass in tandem

The performance equations can then be written as:

$$F_1 = F_2 + (m\omega i) V_2$$
$$V_1 = \left(\frac{\omega i}{k}\right) F_2 + \left(1 - \frac{m\omega^2}{k}\right) V_2$$

This process can be carried out for any number of components. Also, one component can be replaced or eliminated without changing the multiplication of matrices on either side. Thus, a design change in a complicated apparatus can be studied with a minimum of effort.

A parallel connection is defined as having all the inputs of a set of components moving with the same velocity, and also having the sum of the input forces equal to the composite four-pole input force. Similar requirements hold for the output velocity and force.

The composite four pole then has the following parameters for n number of components:

$$\alpha_{11} = A/B,\ \alpha_{12} = \frac{AC}{B} - B$$
$$\alpha_{21} = \frac{1}{B},\ \alpha_{22} = C/B$$

where:

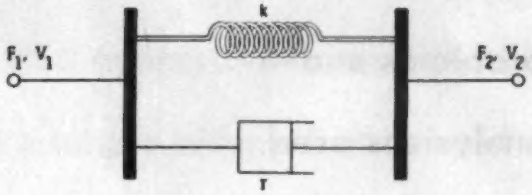
$$A = \sum_{l=1}^{l=m} \left(\frac{\alpha_{11}^{(l)}}{\alpha_{21}^{(l)}}\right),\ B = \sum_{l=1}^{l=n} \left(\frac{1}{\alpha_{21}^{(l)}}\right),\ C = \sum_{l=1}^{l=n} \left(\frac{\alpha_{22}^{(l)}}{\alpha_{21}^{(l)}}\right)$$

A convenient formula which can be used to check four-pole computations is:

$$\begin{vmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{vmatrix} = 1$$

This formula is applicable only to systems which obey the reciprocity principle and for which four-pole parameters have been expressed in consistant units.

An example of the parallel connection of a spring and a resistor is:



$$\alpha_{11} = 1,\ \alpha_{12} = 0$$
$$\alpha_{21} = \frac{1}{r + \frac{k}{\omega i}},\ \alpha_{22} = 1$$

Measuring the Input to a System

Often the design engineer is interested in finding the resultant motion of a piece of equipment connected to a vibrating source. This source might be the structure of an airplane or the chassis of a car. Two characteristics of the source must be known in order to calculate its effect upon any system connected to it. These are the "blocked force" and the mechanical impedance of the source. Sometimes these quantities can be computed from theory. In other cases, it is more convenient to measure them. The "blocked force" is the force which the source is capable of developing when its output point is restrained from moving. The mechanical impedance is the ratio of a complex force, applied at the output of the source, to the resultant complex velocity. An alternate pair of quantities which can be used to describe the source are the "free velocity" and the mechanical impedance. The free velocity of a source is the velocity of its output point when it is exerting no force.

The force-velocity relationship of the source is found from either of the following equations:

$$F = F_{sc} - Z_s V$$
$$F = Z_s V_{sc} - Z_s V$$

where:

Z_s = Impedance of source looking into source from its output

F_{oc} = Blocked force of source output
V_{sc} = Free velocity of source output

A measurement technique can be used if one of the components of a system is too complicated to find its four poles analytically. The blocked and free

mechanical impedances of the input and output are found experimentally and the four poles are then calculated from these values:

$$\alpha_{21} = \frac{1}{\pm\left[Z_{2oc} \cdot (Z_{1oc} - Z_{1sc})\right]^{1/2}}$$

(Choose the sign of radical so α_{21} has a positive real part)

$$\alpha_{11} = Z_{1oc} \cdot \alpha_{21}$$

$$\alpha_{22} = Z_{2oc} \cdot \alpha_{21}$$

$$\alpha_{12} = Z_{1sc} \cdot Z_{2oc} \cdot \alpha_{21}$$

Z_{1oc} is the "blocked" mechanical impedance of the input when the output is not permitted to move. Z_{2oc} and Z_{1sc} are defined similarly.

Solutions for Shock-Type Motion

The effect of a shock or other nonsinusoidal-type motion on an elastic system can be found using four poles. In such cases the system is first analyzed as though a single-frequency sinusoidal motion was driving it. The actual shock-type excitation is then broken down into its sinusoidal components by means of a Fourier integral. Finally, the responses of the system to each of the sinusoidal components of the shock motion are added together by use of a Fourier integral. The result is the desired response of the system to the shock motion.

This method allows the use of four poles previously calculated for components experiencing sinusoidal motion.

Four Poles for Distributed Parameter Systems

The cases shown have been of the "lumped" parameter type. The motion in each case could be described by one or more ordinary differential equations. Four poles can also be used for many "distributed" parameter systems where the motion can only be described by a partial differential equation.

An example of this is a helical spring on which elastic waves are propagating. The equations for the system are:

$$\frac{\partial^2 \xi}{\partial x^2} - \frac{1}{c^2}\,\frac{\partial^2 \xi}{\partial t^2} = 0$$

$$F = -kl \cdot \frac{\partial \xi}{\partial x}$$

where:

ξ = Displacement at a point x and time t
c = Speed of wave propagation = $l(k/m)^{1/2}$
l = Length of unstretched spring
k = Spring stiffness constant
m = Mass of spring

The solution of the equations assuming sinusoidal time variation and subject to the boundary conditions F_1, V_1 at the input and F_2, V_2 at the output yields the four-pole equations:

$$F_1 = \cos\left[\left(\frac{m}{k}\right)^{1/2}\omega\right] \cdot F_2 + i\,(km)^{1/2}\sin\left[\left(\frac{m}{k}\right)^{1/2}\omega\right] \cdot V_2$$

$$V_1 = -\frac{1}{i(km)^{1/2}}\sin\left[\left(\frac{m}{k}\right)^{1/2}\omega\right] \cdot F_2 + \cos\left[\left(\frac{m}{k}\right)^{1/2}\omega\right] \cdot V_2$$

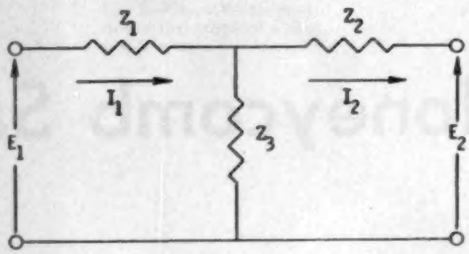
Equivalent Electrical Circuits by Use of Four Poles

As long as the four poles for an elastic system are known and obey the reciprocity relationship:

$$\begin{vmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{vmatrix} = 1$$

an equivalent electrical "T" circuit can be set up directly in a computer.

The "T" circuit shown has three impedances that have the following relationship with the four-pole parameters for the *circuit:*



$$Z_1 = (\alpha_{11} - 1)/\alpha_{21}$$

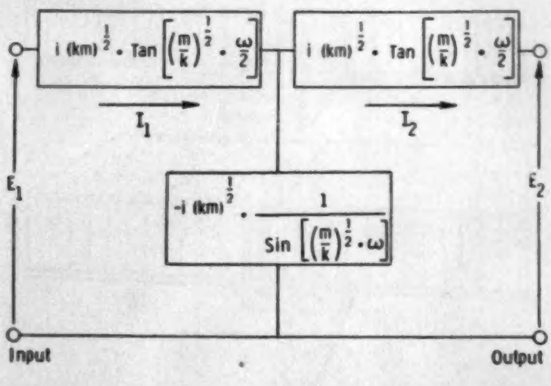
$$Z_2 = (\alpha_{22} - 1)/\alpha_{21}$$

$$Z_3 = 1/\alpha_{21}$$

The impedances in the arms of the "T" can often be easily recognized as simple combinations of lumped parameter electrical circuits. If not, approximate transformations or approximations will yield lumped parameter circuits. These circuits will give the quantitative determination of the performance of the mechanical system when a suitable electrical source is applied. The circuit can also be inspected and its general behavior deduced for a qualitative performance estimate. For the "T" network shown, voltages are analogous to forces and currents to velocities.

It is equally direct to provide formulas that permit work in the "Mobility Analogy."

For the case of the helical spring with distributed parameters, the "T" circuit would be:



Similar circuits can be strung together to simulate a number of components in a complicated mechanical structure. A single "T" can be replaced any time a component is changed in the structure, without affecting the other parts of the circuit.

How to Design a Brazed Honeycomb Sandwich Structure

In the October issue, Mr. Rechlin offered six basic suggestions on how to design for practical, producible, economical structures of brazed honeycomb sandwich.

Here the author illustrates the application of some of these design suggestions and explores the step-by-step theoretical reasoning a designer might use to arrive at a satisfactory design for a hypothetical large missile wing.

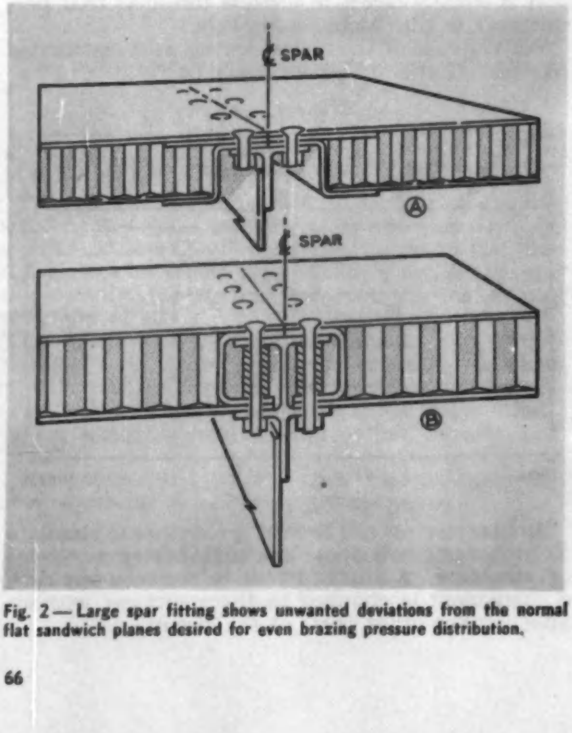


Fig. 2—Large spar fitting shows unwanted deviations from the normal flat sandwich planes desired for even brazing pressure distribution.

Based on paper by

Floyd F. Rechlin

Solar Aircraft Co.

LET us take a hypothetical configuration for a large missile wing (Fig. 1) and assume that the designer must apply the following design criteria to reach his design for the part:

1. A high strength to weight ratio is desired with minimum flutter under load.

2. The surface must withstand maneuver loadings and service temperatures in the range of 1600 F for a few minutes.

3. Aerodynamic smoothness discontinuities are permissible at the wing-to-body intersection, and only the leading edge need be sharp.

4. Major loads are to be transmitted by a central spar and a close-out edge member adjacent to the missile body shell.

5. A shear fitting is to be located near the forward edge.

6. An attachment fitting for launching or ground handling equipment is to be provided in the wing surface.

While satisfying these design criteria, the designer will need to keep in mind the six basic suggestions discussed at length in the October issue. These are, in brief:

1. Minimize detail design subject to the extremely tight tolerance requirements of the brazing process.
2. Make allowances in design for uniform brazing and temperature distribution.
3. Consider brazing temperatures and pressures in the choice of structural material.
4. Insure that the design can be assembled for brazing.

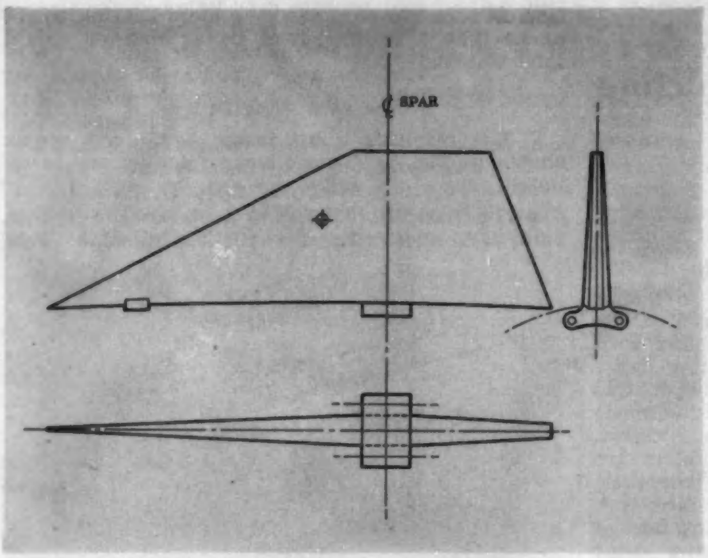


Fig. 1 — Hypothetical envelope configuration for a large missile wing.

5. Incorporate varying core densities to transmit loads internally.

6. Attempt to treat honeycomb sandwich as a material.

The first four of these are requirements of the process which can influence the ultimate design. The last two are manufacturing characteristics which can be used advantageously to increase the efficiency of the honeycomb sandwich structure.

How the Designer Might Reason

Given this background of design information and basic suggestions, we can follow the line of reasoning which a designer might use to develop a practical and producible design for the missile wing (Fig. 1). This reasoning can be told in eight steps:

1. Honeycomb sandwich construction is indicated, not only to meet the requirements for the lightest possible weight, but because of its high rigidity and multidirectional load-carrying properties. The basic material chosen would probably be a high-temperature material such as Haynes No. 25. Knowing the strength properties of the material, the designer's stress personnel can determine basic honeycomb core densities and facing thicknesses.

2. The designer would now most likely ask his materials and process group, or qualified brazing facility, to advise him on the brazing alloy needed to meet temperature requirements. He should also obtain confirmation on the ability of the designated core density to withstand anticipated brazing pressures and temperatures and to be metallurgically compatible with the selected brazing alloy.

3. At the beginning of detail design, the designer should look for any basic design protuberances or deviations from the normal flat sandwich planes desired for even brazing pressure distribution. The large spar fitting, shown in Fig. 2, falls in this category. Moreover, because of its large mass this fitting forms a heat sink which can have great influence on the heat distribution over the sandwich surface at brazing temperatures. Therefore, the decision would most likely be to try to attach this fitting to the wing after completion of brazing.

Keystone of the Design

4. The integral spar configuration now looms as the design keystone for the whole wing construction. While bearing in mind the close tolerances needed for brazing, the designer probably would study a number of spar cross-sections (Fig. 3) to determine which one best satisfies his requirements. The configuration shown at (C) could be his choice if the

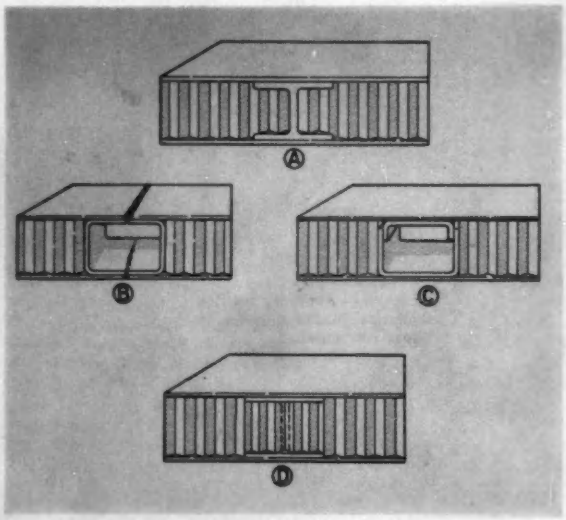


Fig. 3 — Various spar configurations from which designer can make a choice.

How to Design a Brazed Honeycomb Sandwich Structure

continued

thin outboard edge permitted enough access to complete welding operations.

5. The designer would probably turn to a spar cross-section similar to that at (D) of Fig. 3. Here, bending moments are carried by the doublers, with shear transmitted through the connecting dense core. This construction would appear feasible as long as provision can be made for final attachment of the spar fitting. One possible solution is shown in Fig. 4. Here, the spar caps or doublers are formed at the inboard ends to provide a receptacle for later insertion of the forged fitting. The core blanket can be attached easily to the back face of the fitting pocket before brazing, insuring shear transmission through the fitting. Note that the core blanket under the spar caps is made slightly oversize to permit the machining of accurate steps to accommodate the spar cap material. The design shown in Fig. 5 is only one solution to this design problem. Many other configurations are possible.

6. With the spar design established, consideration probably would now be given to the structural configuration of the wing edge member, main core blanket and facings. Many combinations, such as the one shown in Fig. 6, would be studied for their applicability. The idea of using a wrapped skin, as shown, would have to be discarded because of the requirement for a sharp leading edge. Edge member design would probably become a choice between the formed sheet metal channel shown and a doubler-densified core combination. Let us assume the designer settles on the latter configuration in order to eliminate the close brazing tolerances that a curved sheet metal channel would have to satisfy.

The Final Wing Design

7. The resulting wing design could end up as shown in Fig. 7. The following details are to be noted:

- The basic core blanket incorporates a thin band of smaller cell core at the leading edge. This

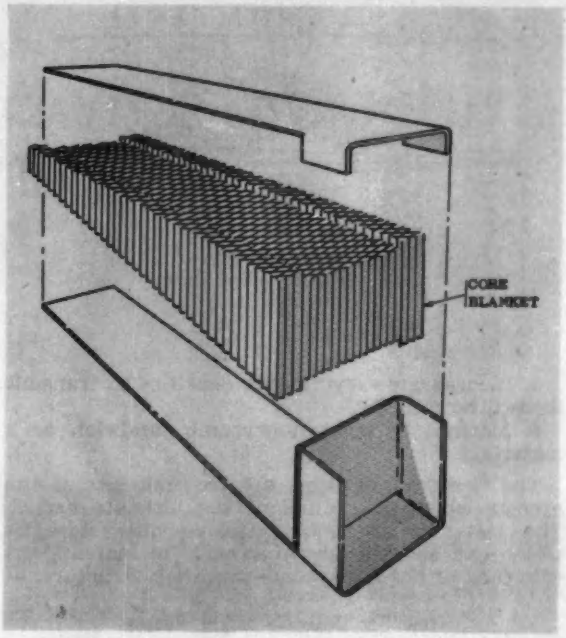


Fig. 4 — Possible solution to spar configuration problem. Spar caps or doublers are formed at the inboard ends to provide a receptacle for later insertion of forged fitting. Core blanket can be attached to back face of fitting pocket before brazing to insure shear transmission through the fitting.

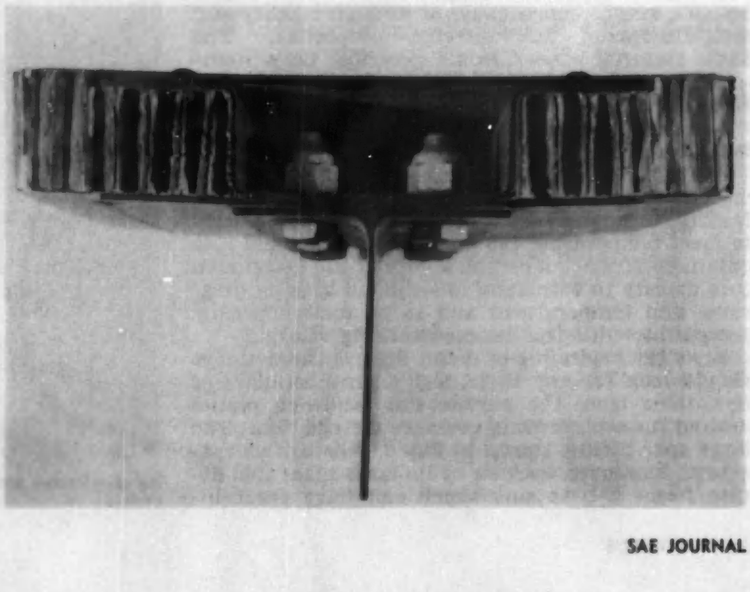


Fig. 5 — Another possible solution to the problem of spar configuration.

permits the core to be machined to a feather line while retaining maximum support.

- The skins are welded together along the leading edge to form a sharp leading edge.
- The forward shear attachment fitting is buried in the core blanket.
- Loads are transmitted along the inboard face by the selected doubler-densified core combination. The doublers, in this illustration, are resistance-welded to the output of the faces prior to brazing, thus avoiding the more costly process of machining a tapered step in the core to accommodate them internally.
- The trailing edge of the wing consists of a strip of denser core to aid in surface rigidity. In addition, the slightly corrugated face of the smaller cell walls could be considered an acceptable substitute for an incorporated closure member.
- At the ground handling attachment point in the wing, another small piece of densified core is spliced in place to accommodate the insertion of the required fitting after brazing operations.

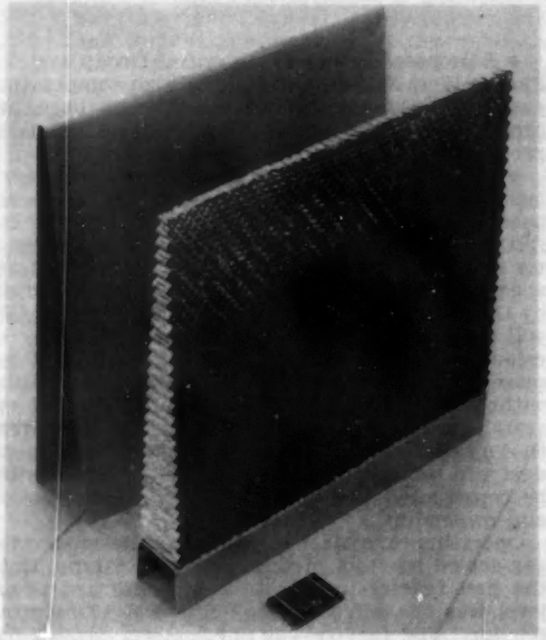


Fig. 6 — Structural configuration of wing edge member, main core blanket and facings.

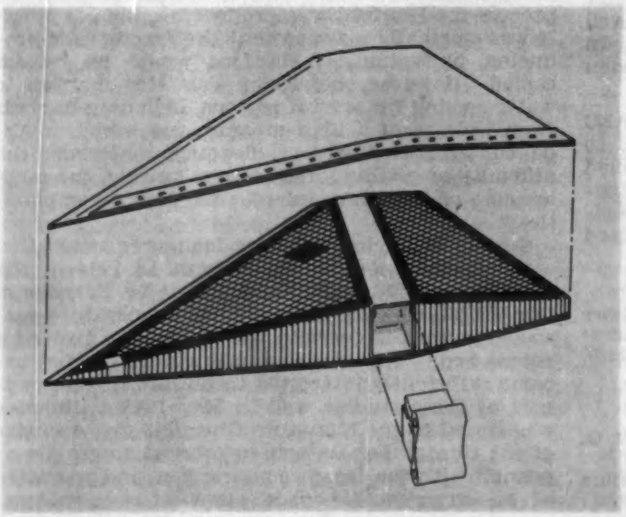


Fig. 7 — Final missile wing design that might result from following recommendations and satisfying design criteria.

8. The designer should engage in a mental step-by-step layup procedure to check the manufacturing feasibility of his design. Progressive steps would be to form the core blanket into a rough shape, splice in all densified core members, machine the blanket to the desired taper, and cut the step in the core needed for the spar assembly. The lower half of the spar cap is then placed in the core blanket and the fitting pocket tack-welded to the faying nodes of the core blanket.

Following this, the top portion of the spar cap is laid in place and resistance-welded to the lower half. The forward shear fitting then would be positioned and tacked to the core blanket. After loading of the brazing alloys, the two skin faces, together, with the previously attached doublers, are laid on either side of the core blanket and the entire unit brazed together. Once brazed, the spar fitting would be slipped into place and fastened by secondary brazing, welding, or mechanical means.

The designer will be aiding the producibility of his design by following these recommendations and usually will arrive at lower costs for the finished component. The final design must reflect the needs of the brazing process as well as the structural and configuration requirements of the designer. If his knowledge of both aspects are combined, it should result in a component pliable in application, but structurally sound.

To Order Paper No. 82C . . .
. . . on which this article is based, turn to page 6.

A feature of the
SAE Nuclear Energy Advisory Committee

Outlook Brightens for Gas-Cooled Nuclear Reactor

RECENT studies made for the AEC show definitely that the gas-cooled reactor has encouraging possibilities. Specifically, the studies indicate that the gas-cooled power reactor:

- **Should show power costs comparable to those of advanced designs of other reactors, such as the pressurized-water and the boiling-water types now under active development in this country.**

- **Has possibilities for improvement in performance just as great as those for the other reactor types.**

The studies on which these conclusions are based were made by Oak Ridge National Laboratory, Kaiser engineers with ACF industries, and Hanford.

By **Charles R. Russell,** General Motors Corp.
(A report to the SAE Nuclear Energy Advisory Committee)

AFTER years of somewhat sporadic development, work on the gas-cooled nuclear reactor, which has attractive possibilities for ship propulsion as well as stationary power plants, is proceeding apace. In recent months the following events have taken place:

- The Maritime Administration and the AEC have contracted with General Dynamic Corp. to perform research and development on a gas-cooled nuclear powerplant for a ship. This is to be a high-temperature reactor (1300–1600 F) with a closed-cycle gas turbine. The program is expected to lead to a prototype reactor in 5–7 years.[1]

- A proposal by the East-Central Group and the Florida West Nuclear Group for a high-temperature gas-cooled D_2O moderated reactor has been accepted by the AEC under the power demonstration program.

- A graphite-moderated gas-cooled power demonstration reactor has been provided for in the bill passed by Congress to appropriate funds for the AEC for the fiscal year 1959. As a first step, industry is being invited to submit proposals to construct a gas-cooled power reactor on a cooperative basis by Dec. 31, 1962. Under the ground rules, the AEC will consider requests for assistance by waiver of established changes for fuel, performance of research and development in AEC laboratories without charge or at less than full cost, and research and development contracts. In the event that a satisfactory proposal is not received from industry, a prototype gas-cooled reactor will probably be constructed and operated under AEC direction and ownership.

Operating experience with graphite-moderated gas-cooled reactors predates any other type, since the first reactor to operate at a significant power level was the aircooled Oak Ridge X-10 research reactor. The facility was not a power reactor but was built as a pilot plant for Hanford. The X-10 reactor, now operating at several megawatts, has served long and usefully for research and for the production of isotopes. Plutonium in gram quantities for the development of the chemical separation process for Hanford was produced in this facility.[2] It was originally planned that the reactors for producing plutonium at Hanford would be helium cooled. However, this design was later changed to water cooling for several reasons, including hazards from leakage of a high-pressure gas, which might be contaminated with radioactive materials, the difficulty of getting large blowers quickly, the large amount of helium required, and design complexities.[3]

Studies of nuclear reactors for power generation were started on an informal basis in 1944 at the Metallurgical Laboratory and in 1944 Dr. Farrington Daniels issued a report on a high-temperature gas-cooled power reactor with the fuel in the form of a pebble bed.[4] The Manhattan Engineer District became sufficiently interested to initiate further support of these studies, and in May 1946 a directive was issued to the Monsanto Chemical Co., operator of the Clinton Laboratory, to proceed as rapidly as possible with the design, construction, and operation of an experimental pilot plant of a high-tem-

---

[1] p. 98, "Research on Power from Fusion, and Other Major Activities in the Atomic Energy Programs." Twenty-fourth Semi-annual Report of AEC, January/June 1958. Pub. by U. S. Government Printing Office, July 1958.

[2] p. 793, "Principles of Nuclear Reactor Engineering," by S. Glasstone. Pub. by van Nostrand, 1955.

[3] p. 113, "Atomic Energy for Military Purposes," by H. D. Smyth. Pub. by Princeton University Press, 1945.

[4] MUC-FD-8 (1944), "Suggestions for High-Temperature Pebble Pile," by F. Daniels.

perature power pile. Loaned employees were obtained from interested industries to staff the project, and development and design work proceeded rapidly. In 1946 the Army released to the public a sketch of a power plant proposed for construction at Oak Ridge. The similarity of the cycle to Calder Hall is interesting.[5] However, the design of the reactor was quite different from the Calder Hall type, with the core structure and moderator being beryllium oxide. Partially enriched fuel was to have been used in an unclad ceramic fuel element (beryllium oxide or graphite) to permit very-high-temperature operation. Helium was selected as the coolant and an outlet temperature to the boiler of 1400 F was considered feasible. The hot helium was to be used to generate superheated steam for the steam power plant. Following the transfer of the Atomic Energy program from the Army to the Atomic Energy Commission, this project was reviewed. In June 1947 the Laboratory was advised that the AEC was not prepared to authorize the design of the power reactor. The investigation of basic problems or components, but at a lower priority than certain other reactor work, was suggested.[6] This decision probably resulted in part from a recognition of the technical difficulties such as thermal stress problems with ceramic fuel elements in such an advanced reactor concept.

A second gas-cooled graphite research reactor of considerable higher design power (30 megawatts heat) was started after the war at the Brookhaven National Laboratory. It was completed in 1950. The design was based on experience with the Oak Ridge X-10 and Hanford reactors. It included several advanced features such as finned fuel cartridges and a split core with the cooling air entering the gap and flowing out through the channels in opposite directions. Five 1500-hp fans draw air through the reactor and filters and discharge through a 320-ft stack.[7]

In 1946 the British selected the aircooled graphite reactor for the production of plutonium and it is noted that among the reasons given for the selection was the inherent safety of this type for operation without the extensive exclusion area considered appropriate for the water-cooled graphite Hanford production reactors. Two small aircooled reactors were built in 1947 and 1948 for research; and production reactors were placed in operation in the 1950–1951 period. They are reported to be large installations. The success with the Windscale production reactors led the British to continue with gas-cooled reactors for power generation and plutonium production at Calder Hall. In these dual-purpose graphite reactors, carbon dioxide at 100 psig is the coolant and the exit gas temperature from the reactor is about 640 F. This hot gas is used to generate steam at 595 F and 210 psia for the high-pressure side of the steam turbines, which deliver 42 megawatts of power per reactor. Later designs of this type of reactor for operation in 1960 will have a maximum gas outlet temperature of 745 F, and it appears that additional increases in temperature will be possible. Thus we find gas-cooled power reactors now operating successfully in Great Britain, and fulfilling a vital economic need, although the gas temperatures are too low for the application of a gas turbine power cycle. Also, experiments are reported by the British on ceramic fuel elements which may permit gas temperatures of 1400 F. The French have followed a similar route in their reactor program. Their first plutonium production reactors are gas cooled and produce both power and plutonium.

reactors for commercial power

Several studies have been made of the gas-cooled reactor for commercial power generation in this country, including work by Commonwealth Edison Co. and Public Service Co. of Northern Illinois reported in 1952.[8] This was an evaluation of a helium-cooled reactor generating steam at 525 F. There are reports available on closed gas turbines and steam cycles by the Allis Chalmers Mfg. Co. for helium-cooled reactors.[9] Dr. Farrington Daniels has proposed advanced designs of gas-cooled reactors with graphite core construction and nonmetallic fuel elements. In one design a helium-cooled graphite-moderated reactor produced a gas outlet temperature of 1350 F. This hot gas was to be circulated through a heat exchanger to operate a closed-cycle gas turbine.[10] The heat exchanger would prevent any radioactive materials from entering the power generating equipment and the temperature produced in the closed gas turbine cycle of 1250 F would be high enough for efficient operation. The City of Holyoke, Mass., proposed a gas-cooled power demonstration reactor to the AEC. This power plant was to have used a closed-cycle gas turbine to produce 15 megawatts of electric power. Atomics International[11] and American Radiator[12] have published studies of gas-cooled power reactors.

gas-cooled reactor experiment

More active development of a gas-cooled power reactor was started in 1956, with the initiation of the Gas-Cooled Reactor Experiment to be constructed at the National Reactor Testing Station in Idaho by the Aerojet-General Corp. This is to be a flexible experimental facility permitting the testing of a variety of core materials. No power generating machinery is to be included and therefore the heat will be dumped in a heat exchanger. The reactor is to be critical in 1959.

---

[5] p. 297, "Introduction to Pile Theory," by C. Goodman. Pub. by Addison-Wesley Press, Inc., 1952.

[6] Mon-N-383 (1947), "Summary Report on Design and Development of High-Temperature Gas-Cooled Power Pile," by C. McCullough.

[7] pp. 385–442, "Research Reactors." Pub. by the U. S. Government Printing Office, 1955.

[8] Report CEPS-1101 (May 1952), Commonwealth Edison Co. and Public Service Co. of Ill.

[9] Report NP-3683 (January 1952), Allis Chalmers Mfg. Co.

[10] *Nucleonics*, Vol. 14, March 1956, pp. 34–41: "Small Gas-Cycle Reactor Offers Economic Promise," by F. Daniels.

[11] Reports NAA-SR-1833 and NAA-SR-1955, "Evaluation of Calder Hall Type of Nuclear Power Plant."

[12] Report AECU-3398, "Comparison of Calder Hall and Pressurized-Water Types."

Plastics for Nose Cones . . .

Based on paper by

Irving Gruntfest

Aerosciences Laboratory, General Electric Co.

NOT only do plastics decompose slowly, but in doing so they absorb considerable heat and generate large volumes of gas which interferes with the convective transfer of heat to the surface.

Erosion of plastics varies markedly with temperature. This is shown in Fig. 1 for a selected group of plastics. The group includes two glass-reinforced phenolic resins, one quite rich in glass, the other quite rich in resin; a Refrasil-reinforced phenolic resin; and a nylon-reinforced phenolic resin which contains no inorganic material. At each of three temperatures, the best material is rated "1" on the graph and the others are then rated according to their relative erosion rates. (The curves indicate relative performance in the group. They do not indicate that the nylon-reinforced material, for example, erodes more slowly as the temperature is raised.)

Conditions other than temperature were varied in the tests that furnished these data. The tests were part of a program run in hot-air generators, chemical flames, a solar furnace, and a variety of electric arc devices. Therefore the studies of thermal erosion were made in gases with widely varying chemistry, temperature, and enthalpy. But it is very likely that temperature is the decisive factor.

In Fig. 1, notice that the material which is relatively least durable at 2000 C is relatively most durable at 7000 C. Furthermore, the use of a more refractory reinforcement is of no consequence in the 2000 C test or in the 7000 C. That is, its rating is comparable to a glass-reinforced phenolic with the same inorganic/organic ratio. In contrast, the material reinforced with the refractory high silica glass fiber is significantly better at 3000 C.

Furthermore, the influence of resin content is quite different at the three test temperatures. Higher resin content leads to lower relative erosion rates at 7000 C and to higher relative erosion rates at 2000 C.

The table shows the theoretical heat-absorbing capacity — that is, the integrated specific heat — for a variety of materials from room temperature to 5000 K. In addition, the relative maximum volumes of gas generated from each in the course of the heating process is given. These data provide a rational basis for considering organic materials for parts exposed to very hot gases, since among structural materials, the reinforced organics have the highest potential heat-absorbing and gas-generating capacity.

Of course, the relative values shown in the table will depend on the upper limit of the integration, that is, the maximum temperature to which the materials are raised. The organic materials have the highest rating only if this temperature is high enough to dissociate hydrogen molecules into atoms. This process takes place at about 3700 K. Notice in Fig. 1 that it is only above this temperature that the all-organic material (nylon-reinforced phenolic) shows superior performance.

Certain physical properties such as the melting point of a material are also clearly relevant to its performance. That is, a low melting material is not at all likely to absorb the amount of heat shown in the table when it is exposed to a hot gas because the liquid could flow off the surface before it got much above the melting point. In this case, only the heat absorbed up to the melting point could be effective.

Some attempt has been made to take the melting process into account in the data shown in the last three columns of the table. The melting points of some of the materials are listed together with the maximum percentage of the theoretical heat absorption which can be expected through the melting point.

Here perhaps is an explanation for another of the reversals shown in Fig. 1. That is, in the 2000 C gas neither the melting of the glass or of the Refrasil plays an important role in the erosion. The performance of the two products is therefore not distinguishable.

In the 3000 C gas the lower melting glass fiber does fail more rapidly and thus contribute more to the erosion than the higher melting Refrasil. Under these conditions, important advantages may be gained by the use of the more refractory reinforcement. At the highest temperature, rapid melting of both fibers can be expected, and indeed vaporization may be the decisive process. Here again the higher melting point of the Refrasil brings no advantage.

The table gives no melting points for the organic materials because the melting points of these ma-

and other parts of hypersonic vehicles are feasible because plastics decompose slowly. In this respect organic plastics may be more advantageous than metals.

terials depend on the details of their molecular structure more than on their gross compositions. Furthermore, the materials of greatest interest, the phenolic resins, do not melt at all when heated but decompose directly into gases. Here again is a purely chemical facet of the problem of thermal erosion.

The rating of carbon in the table is noteworthy. As would be expected, under severe conditions of exposure carbon is perhaps the most erosion-resistant material known. However, its structural properties up to 1500 C and thermal conductivity complicate some of the design problems which occur in missiles.

The properties of carbon are pertinent because under the best conditions a major product of the thermal decomposition of organic plastics is carbon. In fact, it may be contended that the use of organic plastics is merely a devious way to present carbon to the hot gaseous environment.

To Order Paper No. 82A . . .
. . . on which this article is based, turn to page 6.

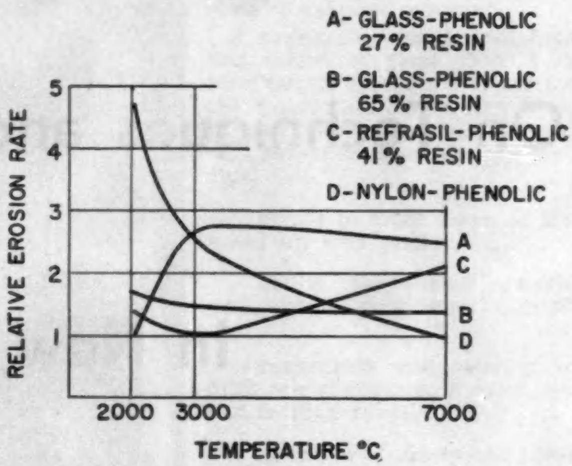


Fig. 1 — Relative erosion rates for different plastics as a function of temperature.

Thermal Properties of Various Substances

Substance	Heat absorbed estimated by integrating specific heats from 300 to 5000 K, cal/g	Relative equilibrium volume of gas generated per g at 5000 K, moles	Melting temperature, C	Boiling temperature, C	Heat absorption efficiency, %
Hydrogen H_2	67,000	1.0	−260	−253	0
Organic plastic $(CH_2)_n$	24,000	0.21	——	——	—
Organic plastic $(CH)_n$	20,600	0.15	——	——	—
Graphite C	16,670	0.08	——	4200	99
Water H_2O	14,500	0.16	0	100	0
Beryllium Be	9,876	0.11	1278	2970	6
Beryllia BeO	7,080	0.08	2530	3900	26
Teflon $(C_2F_4)_n$	6,300	0.06	——	——	—
Cellulose $(C_6H_{12}O_6)_n$	5,760	0.10	——	——	—
Magnesia MgO	5,500	0.05	2800	3350	24
Helium H	3,525	0.25	−272	−269	0
Silica SiO_2	2,800	0.05	1710	2300	22
Copper Cu	1,600	0.016	1083	2336	6

Engineers Exchange Information On Techniques and Designs Required In New Pattern of Defense

TWENTY-FIVE HUNDRED SAE members and guests heeded the call of "the little Martian" to the sessions and Aircraft Engineering Display of the SAE National Aeronautic Meeting held at The Ambassador Hotel in Los Angeles September 29 – October 4.

The first two days of the Meeting were given over to a Manufacturing Forum. The next three days were devoted to sessions on design of space vehicles and aircraft and the operation of transport aircraft. The Meeting ended with a dinner-dance on Saturday evening.

J. L. Atwood, president of North American Aviation, presaged much of the discussion at the Meeting when he said in a luncheon speech on the first day, "It's time to shift our mental gears for the new pattern of defense." Atwood numerated five trends growing out of the switch from an air arsenal of manned aircraft to one of both manned aircraft and missiles:

1. More efficient defense equipment and more effectiveness in the individual unit of equipment.
2. Increasing specialization in technology.
3. A decline in quantity of defense equipment and added emphasis on development rather than production.
4. Mounting development costs.
5. Greater reliance on each line of development.

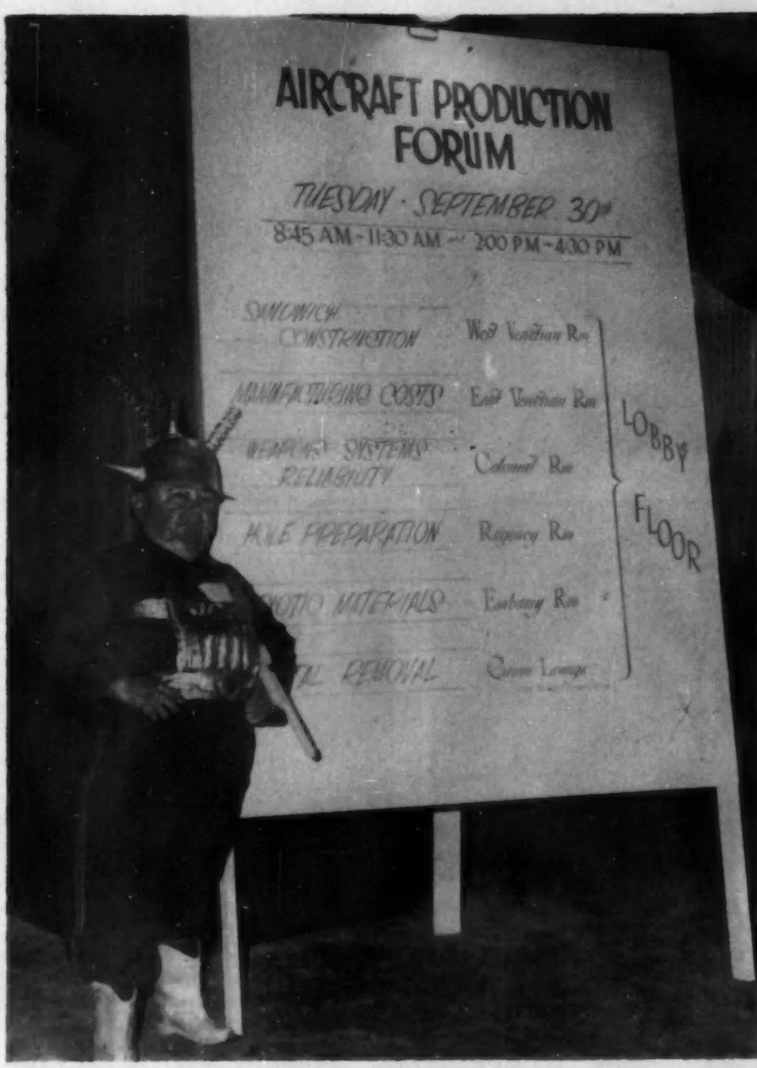
Development costs will be so high that we won't be able to afford duplication of design effort on equipment for a particular mission. The military services will choose the contractor for a project at a much earlier development stage. The decision will, therefore, be made largely on technical and managerial capabilities of the competitors, rather than on demonstration units, Atwood believes.

The result is that, to survive, companies are cultivating a new flexibility. A company may find its relation to a second firm is such that it buys from the second on one project, sells on another, and competes on still another. Large companies work with small companies and benefit from their special skills.

This voluntary teamwork, Atwood pointed out, is far more efficient than government coordination, which is practised in so many other countries.

At first, he said, it was hard to find small businesses competent to handle the complications of modern weapons systems. But many small businesses have developed very useful special capabilities. They have taken their places among the proliferating tiers of subcontractors.

The trends that Atwood out-



THE "LITTLE MARTIAN," television actor Billy Rhodes, announced the events of the Meeting daily throughout the hotel lobby.

lined are borne out in the organizational setup of Convair's new Astronautics Division, another luncheon talk showed. J. R. Dempsey, general manager of the division, disclosed that it has 3000 suppliers — 300 of whom are engaged in development work on contracts with Astronautics. Although the plant is producing the Atlas intercontinental ballistic missile, it employs more engineering personnel than factory workers.

Dempsey noted further that of all the people in all the plants who are helping produce the Atlas, less than 10% of them are at work on the Atlas airframe. With missiles, he said, the airframe manufacturer merely takes care of what the other contractors don't supply. Mostly that's testing. He does also, of course, put much effort into the ground support equipment for the "bird."

It's no easy task to determine which of several new weapons systems offers the greatest potential effectiveness, Vice-Admiral J. H. Sides, USN remarked. That's why the Weapons Systems Evaluation Group has been formed by the Department of Defense. Admiral Sides is director of the WSEG. He expressed pride in the fact that in his organization there are about 30 military officers of the three services and 100 civilian specialists in engineering, economics, and other disciplines — and all work jointly and in real harmony.

Their mission is "to provide the Department of Defense with comprehensive, objective, and independent analyses and evaluations under projected conditions of war, which will include but will not necessarily be confined to: present and future weapons systems; the influence of present and future weapons systems upon strategy, organization, and tactics; the comparative effectiveness and costs of weapons systems."

A strong plea for the seaplane was voiced by Capt. Donald B. MacDiamid, operations officer for the Coast Guard's eastern area. In his luncheon speech, he urged that future seaplane designs provide:

— ability to touch down at low speed and stop quickly.

— ability to take-off quickly and with a very short take-off run.

— ruggedness and stability to drift or maneuver on a rough sea and in high winds.

A sampling of scenes and ideas from the Meeting appears on following pages. The panel secretaries' reports of the 12 panel discussions constituting the Manufacturing Forum will be made available as soon as all reports are received as SP-325 at $2.00 to SAE members and $4.00 to nonmembers. Copies of the papers presented at the technical sessions are available individually at 50¢ to members and 75¢ to nonmembers.

SAE Journal will publish abridgments of the Manufacturing Forum reports and the papers. A few appear in this issue. The others will appear within the next several issues.

(In addition to the sessions for which papers are available there were three confidential sessions, which were open only to SAE members cleared by the military to attend. They dealt with variable air inlet control systems, missile auxiliary power systems, missile testing, and vernier rockets.)

More about the Meeting→

MANUFACTURING FORUM was planned by an 11-man committee, some of whom are shown at top. Panel chairmen met Sunday afternoon, the day before the Forum began, for final instructions (below left). Charles S. Wagner of Lockheed received a plaque honoring him for his service as Forum Chairman from SAE President William K. Creson. T. Claude Ryan, sponsor of the Forum was unable to attend and was represented by Frank W. Fink of Ryan Aeronautical.

ALF ENSRUD (in lighter coat) of Lockheed received the Wright Brothers Award for his paper on application of high-strength steels to supersonic aircraft, which he presented in April 1957. Frank W. Fink, chairman of the Wright Brothers Board of Award, presented the medal, scroll, and check to Ensrud at the luncheon on Thursday, October 3.

The Wright Brothers Medal is awarded annually to the author of the paper judged best in the field of "aerodynamics or structural theory or research, or airplane design or construction."

notes from panel-hopping through the two days of the manufacturing forum

ground support for missiles

There's a need for more standardization of ground support equipment — maybe not whole units, but components and bits and pieces. Standardization has lagged because neither the military nor industry has taken the initiative. The military doesn't have the personnel, and industry doesn't have the money for standardization in its contracts nor the entree into other companies.

Perhaps industry and the military can get together through SAE committees to accomplish the standardization that is needed in this field.

fabricating high temperature sheet

Sure it's expensive to form the new high-temperature sheet materials. But don't worry too much about costs. If you can't fabricate high temperature materials, you're going to be out of business anyway.

Some of the new aluminums contain as much as 25% alloying elements. To develop high strengths, you should solution treat, air cool, and age. No water quench is needed.

procurement

In procurement of supplier-designed special equipment, the prime contractor must make the vendor a part of his team. There must be provision for engineer-to-engineer communication between prime and vendor.

One prime has set up a numbered "vendor engineering memorandum" system. The memorandum is not part of the contractual agreement; it's not even a letter. But the memos, which are handled by a correspondence group, serve to record the many minor exchanges that must be made to keep both sides informed on needs and on design decisions.

test equipment for production

"One accurate measurement is worth a thousand expert opinions." That's the philosophy at one big aircraft plant.

The room where production test equipment is calibrated against the plant's standard should be temperature controlled to ±2F. However, the base temperature doesn't matter much as long as it is held. The room must be free from vibration and dust.

how to build quality

Workers will take more interest in maintaining tolerances if you explain to them why close tolerances are needed. That goes for every worker from plant superintendent right down to the man at the machine. You may be surprised at how readily operators understand the technical explanation — and how well they respond to this kind of appeal to their pride of workmanship.

low-quantity, low-rate production

As a result of the switch from high-production manned aircraft to low-production missiles, there'll be fewer women mechanics in our plants. That's because the mechanic will be doing one job one week and another job the next week. He'll have to have a number of skills. Women don't work enough years to pick up the variety of skills. Besides, you can't ask them to do heavy lifting. They do, however, usually adjust more readily to different tools.

exotic materials and processes

Fissionable materials bring three special problems to the manufacturing engineer: accountability, safety, and criticality. The government requires users of uranium 235 and 233 and plutonium to account for every bit of these government-allotted materials. The government wants its material back — and in a condition in which it can be reused. That means that the materials must be processed so that a minimum of scrap is formed.

Uranium is not dangerous as long as it stays outside the body. But grinding it releases a powder which when breathed can cause illness.

Fissionable materials must be handled in batches small enough not to sustain a reaction — that is, in amounts less than the critical mass.

sandwich construction

One major producer of sandwich structure always fabricates the core treated to its final physical properties, usually heat-treated to 230,000 psi ultimate strength.

In intricately shaped sandwich structures, it's sometimes necessary to etch out the copper mandrels used for welding.

control of manufacturing costs

Rate of learning, as reflected in the learning curve, improves as the production schedule is stepped up. But performance improves as production is cut. That's because the less experienced workers are taken off the job.

The "learning curve" is really a job-time reduction curve.

metal removal

In machining honeycomb core with coated abrasive belts, one shop figures it can remove 12 cu in. of honeycomb core metal per square foot of belt area before the belt is worn out. (That's with 180 aluminum oxide grit and 622 lubricant.)

Coated paper belts less than 50 in. wide cost about 45¢ per sq ft.

Some users of honeycomb who now receive core material in the annealed condition hope to be able soon to get it partially heat-treated (condition C).

weapon systems reliability

It isn't so much that *reliability* is expensive. It's unreliability that's really expensive. But the measurement of reliability is costly.

It might be wise to make some money available to vendors for improving the reliability of the units they supply, just as it is allotted to primes. Such a practice might make a vendor more willing to admit the unreliability of his product — which he naturally isn't eager to do now when he thinks the admission will cost him money.

hole preparation

Recently developed portable broach pullers and special pull broaches produce extremely close tolerance holes with consistent results. The broaches are pulled through pilot holes by a hydraulic puller driven by an air hydraulic power unit. In sandwich assemblies of hard and soft materials, the broach produces a hole of the same close tolerance in both materials — and it doesn't scratch.

Secretaries' reports of these panels will be available in full in multilith form as SP-325.

Capsule reports of technical sessions at the SAE National

Wednesday

high-temperature materials

Plastics surpass metals for use in structures exposed to hypersonic gas streams. The plastics decompose gradually, absorbing much heat and giving off large volumes of gas, which acts as a heat shield. Metals melt and trickle away, making them less suitable for nose cones and similar parts. (Paper 82A)

Chance Vought is using SAE 4340 steel heat-treated to hardnesses of Rockwell C50-53 and minimum ultimate strength of 260,000 psi in the structures of its aircraft and missiles. Successful usage requires meticulous selection of billets and great care in machining, heat-treating, and finishing. (Paper 82B)

Honeycomb sandwich manufacturing technology is reaching the point where the sandwich can be regarded as a material, just like sheet materials, and not a structure built up for each application. Soon it will be possible to take flat honeycomb panels off the shelf, rough cut them to size, form them to the desired shape or curvature, finish machine them, and attach the edge members by brazing, welding, or mechanical joining. (Paper 82C)

shock and vibration

SAE Committee S-12's new shock and vibration design manual will tell engineers, without sophisticated analysis, how to protect delicate equipment from shock and vibration damage. (Paper 83A). The vibration picture was rounded out with information on the reliability of aircraft electrical components in military service (Paper 83D), accelerated vibration fatigue test techniques (Paper 83C), and the broad temperature range now covered by synthetic-rubber shock-isolation mounts. (Paper 83B)

aerodynamic labs and test facilities

Lockheed Missile System Division has a new arc-heated blow-down hypersonic wind tunnel. Electrodes and throat section are fabricated of tungsten, which shows less erosion than copper or steel. (Paper 84A)

The Convair High-Speed Wind Tunnel is a pressure blowdown type. It has two 4×4-ft test sections, one for transonic and one for supersonic testing. Sea water is used for compressor intercooling. A bed of alumina balls helps maintain nearly constant stagnation temperature during a run. (Paper 84B)

Proposals now being made to drive hypersonic wind tunnels by magnetohydrodynamic means may produce the energy required, but who needs to fly through a solar prominance? Perhaps someone will find a way of handling gas of such high temperatures and pressures and of recombining the plasma to the type of atmosphere the

Thursday

optimizing aircraft utilization

For DC-8 and 707 jet transports domestic direct operating costs will be on the order of $1000-1200 per flight hour. With overhead, total hourly cost will be $1800-2000. (Paper 86A)

It may be better to have several kinds of transports in a fleet than one. Maintenance and training, the areas which benefit most by standardization, account for only 8–10% of the total cost. Hence, most of the savings expected from use of a mixed fleet over varied routes will be realized. (Paper 86B)

An 18.7-ton load of air freight that takes 4 hr to load and unload by hand can be loaded by a new mechanized preloaded method in 20 min. (Paper 86C)

cabin conditioning

Air conditioning system of the DC-8 does not include a dehumidification unit. It is felt that with the carefully designed air distribution system, and occupied-space temperatures between 74 and 77 F, humidity will be satisfactory for the periods the passengers and crew will be in the airplane. The Freon system evaporator, which will be in action on high-humidity, hot days, is inherently a dehumidifier. (Paper 87A)

Cooling orbital space vehicles by boiling stored water and ammonia looks like a good bet. The high-specific-heat water will carry most of the cooling load with the ammonia helping out on take-off and landing when the water can't boil. This system is high in reliability because of the few moving parts and can be easily serviced. Storing the water and ammonia away from the boiler has a weight and volume advantage over an integral boiler-coolant combination. (Paper 87C)

Fresh air for the Lockheed Electra cabin comes from the engine inlet ducts of the inboard nacelles. It passes through engine-driven compressors to a refrigeration unit, then is mixed with recirculated air. Then the mixed air goes through a filter, and electric heater, and a Freon evaporator. (Paper 87C)

missile guidance and control

An approximate minimum-time steering program for a trip between the orbit of Earth and the orbit of Mars, for a vehicle with constant thrust-to-mass ratio of 10^{-4} Earth g, has been calculated. The program results in an excess of angular momentum over local circular value during the first part of the trip, where the radial velocity is increasing. During the last part of the trip, there is a deficiency of angular momentum in comparison to the local circular value. (Paper 88A)

The pilots' peace-of-mind has forced the development of an automatic flare system for landings that plots a new and smooth approach every time the plane is thrown off course by a gust. Simple return-to-fixed-path systems will do a good landing job but leave the pilot with an unnatural feeling that destroys his confidence in such systems. (Paper 88C)

training pilots for turbine transports

The new transports tend to require of pilots less physical skill but greater operational background. Aerodynamics as applied to the specific airplane needs more and more emphasis. For example, a good basic knowledge of aerodynamics as applied to slow-speed drag character-

Papers on which these capsules are based are available in full in multilith form from SAE Headquarters.

prototype is expected to fly in. Then we'll have a truly hypersonic, long-duration tunnel. (Paper 84C)

noise suppressors and thrust reversers

Two different thrust reverser types will grace the Boeing 707 and the Douglas DC-8. A target reverser, mounted in an ejector was chosen by Douglas. It saved weight by combining the reverser with part of the sound suppression system and also avoided the sealing and temperature problems inherent in a cascade tailpipe-mounted reverser. (Paper 85A) The Boeing reverser is an extension of the work done for the Comet III by Rolls-Royce and De Havilland. The original decision for an "upstream" reverser was made because "downstream" target reversers are large when mounted behind silencers, encounter fluctuating loads, and have high operating loads. (Paper 85C)

Turbine engine internal noise is radiated through the air induction system. It could result in mechanical and material failures. Therefore, early in the design of the basic engine, attenuation systems should be considered and matched to the engine to minimize performance losses. (Paper 85B)

istics of modern aircraft may prevent landing accidents caused by excessive sink rates.

fuel systems for jet transports

Each engine of the DC-8 transport has an independent self-sufficient fuel system. For reliability reasons valves controlling the supply of fuel to the engines are mechanically operated. Engine-driven pumps deliver fuel to the engines if accessory power fails. (Paper 89A)

The Boeing 707 has seven fuel tanks — four mains, two reserves, and a center tank. Each main tank provides independent, uninterrupted supply for its engine during takeoff and landing. The reserve tanks reduce bending moments. The center tank is a means of controlling center of gravity. (Paper 89B)

The only way to insure that turbine engines get fuel as extremely clean and free from water as they need is to practice unrelenting good housekeeping all the way from the refinery to the airplane tank and engine. (Paper 89C)

human engineering for space flight

Chances of being struck by meteoroids big enough to endanger space cabin structure are slight enough to be an acceptable risk. (Paper 90A)

Leaks through structures and seals may prove to be more important than meteoroid penetrations. For extended operations cabins must be hermetically sealed. (Paper 90B) Even the smallest meteoroid holes will have to be rapidly detected and sealed. (Paper 90B)

See order blank on page 6.

escape systems for supersonic aircraft

The Martin-Baker A5 Ejection Seat qualifies as an escape system in the F9F-8T combat aircraft at ground level within a speed range of 95-450 knots at yaw angles up to 15 and 4 deg, respectively. (Paper 91A)

It will soon be possible to provide safe ejection from open ejection seats at zero speed and zero altitude — say, from a flaming aircraft on the runway. The high-speed limit of safe ejection from an open ejection seat is between Mach 2.0 and 2.5; higher speeds demand ejection capsules. (Paper 91C)

The escape system — be it an open ejection seat or a capsule — should offer the least compromise to aircraft performance, yet provide adequate protection of the maximum probable escape conditions. (Paper 91D)

nuclear propulsion

The reactor for an aircraft nuclear powerplant will have to be checked at low power at the manufacturing site. (The rotating parts of the powerplants can be checked with an alternate heat source.) The reactor fuel elements will have to be disassembled and shipped to the assembly site individually to avoid going critical. (Paper 92B)

Lockheed's new Georgia Nuclear Aircraft Laboratory provides for the evaluation of the effects of radiation on operating aircraft systems. (Paper 92C)

Under high-level radiation, lubricants may fail quite suddenly — either from cross-linking to a solid material or from loss of heat acceptance capability. (Paper 92D)

missile handling and storage

The Hercules hydraulic system reservoir is pressurized lightly with dry nitrogen. That's the result of experience with the Nike Ajax launcher. The Ajax's rain cover over the air breather didn't keep out water from hose downs. And the open reservoir did not prevent internal condensation from the atmosphere. (Paper 93B)

The Falcon missile consists of 10 field-replaceable units. Some can be replaced in only 5 min, and the most complicated take only about 30 min. (Paper 93C)

constant-speed drives

Extreme heat is the problem to lick if constant speed drives are to achieve their expected peak usage in the next 10 years. Aircraft designers have to find a heat sink for the 300 Btu/min produced by a 40-kva drive. (Paper 94A) Hydraulic constant-speed drives can serve at 700 F temperatures if high-alloy steels are used instead of aluminum and magnesium and if lubricants are protected against oxidation. (Papers 94C and 94D) Two different approaches to the drive problem are the mechanical CSD and the pneumatic CSD. (Paper 94B)

STOL-VTOL aircraft

On takeoff vertical-attitude VTOL craft are generally safer than conventional aircraft. Everything on VTOL craft *has* to be working right or you don't get off the ground. (Paper 95A)

The X-14 experimental aircraft is a VTOL test bed. It is providing valuable data on ground effects, propulsion system installation, performance and stability characteristics, and effects of pilot techniques. (Paper 95B)

From Mach 0.2 to 0.6 or 0.7 propeller-type VTOL aircraft seem most promising. Around Mach 0.8 jet-propelled VTOL systems become more advantageous. In the Mach 2+ region, where thrust requirements are about the same for cruise and for take-off and landing, turbojets are still the most suitable. (Paper 95C)




AIRCRAFT ENGINEERING DISPLAY supplemented the Meeting's discussions with exhibits of advanced developments from 100 manufacturers. Products shown included high-strength materials, sandwich structures, air conditioners, hydraulic and pneumatic equipment, fasteners, vibration mounts, filters, and ground servicing equipment. This year's Display was the largest ever held as part of an SAE National Aeronautic Meeting on the West Coast.

PHILIP M. KLAUBER (left) of Solar Aircraft, chairman of the committee for the Meeting, received a plaque in appreciation of his work from SAE President William K. Creson.

CARGO CONTAINER is for use with DC-8 transport. Container will be preloaded, rolled to airplane and put aboard, flown to cargo destination, and off-loaded. Cart is glass-fiber-reinforced plastic and weighs 85 lbs. That's Ray Kelly smoothing the decal.

FOUR LUNCHEONS featured (Monday, upper left) J. L. Atwood of North American Aviation as speaker and B. C. Monesmith of Lockheed as toastmaster; (Tuesday, upper right) Admiral J. H. Sides of the Office of the Secretary of Defense as speaker and R. R. Miller of Northrop as toastmaster; (Wednesday, lower left) Capt. D. B. MacDiarmid, USCG as speaker and Harrison Holzapfel of AiResearch Manufacturing as toastmaster, and (Thursday) Col. Paul Nay of Air Research and Development Command as toastmaster and J. R. Dempsey of Convair-Astronautics as speaker.

DR. WILLIAM BALLHAUS (left) of Nortronics with Milt Kuska of Northrop. Ballhaus is chairmain of the committee for the SAE Aeronautic Meeting scheduled for October 1959.

PANEL OF EXPERTS ON PILOT SELECTION AND TRAINING for jet transports lunches in Coconut Grove before its session. Carl Christenson of United Air Lines (seated third from right) was chairman. Christenson is an SAE vice-president.

Russian Production

The U.S.S.R. still looks upon the United States as the leader in modern industry but their aim is to equal or better any industrial processes we have now.

Based on report by

Nevin L. Bean

Ford Motor Co.

NEVIN L. BEAN, technical assistant to the general manufacturing manager, Automatic Transmission Operation, Ford Motor Co., was one of three American engineers who toured industrial facilities in the Soviet Union. The accompanying article summarizes Bean's observations of production and design in the U.S.S.R.

THE SOVIET SYSTEM is not now geared to provide a standard of living comparable to ours in America, but production facilities are being expanded rapidly. It is entirely possible that they can rather quickly narrow the gap between their capacity and ours. They already have men who know how to improve productivity and they are training more.

On the whole, the Russian plants we saw are not as productive as those in this country. They are not as well organized, not as clean, and not as well lighted. Most material handling systems are obsolete.

However, we found that many of these adverse conditions are in the process of being changed. New automatic production machines are being designed and built, and the engineering on some of these lines would be a credit to any engineering group anywhere.

The interest in automation appeared to be greater in Russia than it is in the United States. They are no longer building manual production machines if automated lines can be made. If plans we saw are carried out, Russian factories will have the machinery and techniques to make giant production strides within the next five years. Within 10 years many of their production facilities and techniques may be superior to ours, unless a new emphasis is placed on automated production designing in this country.

Perhaps the most important key to future Russian advances in automation lies in an organization called "ENIMS" in Moscow. This is the Experimental Scientific Research Institute for Metal Cutting Machine Tools.

The ENIMS organization works entirely for the machine tool industry, and its activities come under the Ministry of Machine Tool Building and Instrumentation. It controls design of all machine tools constructed in the Soviet Union. While other factories may design tools, they must have ENIMS approval before adoption. ENIMS personnel indicated that their organization is generally concerned with plans for equipment of the future, leaving to other factories the design and building of machines which are up-to-date by present-day standards.

5-, 10-, and 15-Year Plans

In general, industrial programs are planned on a five-year basis. ENIMS coordinates this planning, which includes the scheduling of installation of production machinery in factories. Therefore, ENIMS is able to control the types of machines built, the uses to which they are put, and their distribution among various industrial plants.

Beyond the five-year plans, there are 10-year and 15-year plans, but these are rather sketchy. However, ENIMS controls their general direction. This organization plans tools at least four to five years ahead, largely from information possessed by the local staff. However, it may also draw upon information from industries concerned, as well as material gleaned from the foreign and domestic technical press. (There is a technical library of more than 200,000 volumes, with a special department that screens, analyzes, and interprets technical press articles from other countries. Processes con-

Making Rapid Strides

sidered of sufficient interest are described in one of two ENIMS publications which are distributed throughout industry.)

ENIMS strives for balanced design, taking into account the speed and capacity of machines, future possibilities for automation, continuous cutting, and optimum production of machines over their lifetime. Careful attention is given to calculations of obsolescence and general design problems.

Plant Tours

We saw some very interesting mechanical and electronic applications of automation during our tour of the ENIMS plant. One outstanding item was an automatic balancing machine designed to balance an electric motor armature. The machine determines the area of unbalance, then automatically sets into motion cutting heads which cut out just enough metal to correct the unbalance, while the armature is being cycled through the machine. We also saw many tracer-type lathes — both vertical and horizontal — and boring mills of various sizes which were being constructed at this plant. It was here that we saw an application of electrolytic erosion as a metal forming process.

In addition to the ENIMS design institute, we visited two plants where machine tools are made. One, Ordzhonikidze plant was about 25 years old, and the other, known as the Krasny Proletariat, was about 100 years old.

Ordzhonikidze specializes in making boring equipment. Most of the manufacturing equipment in the plant was foreign made and has not been modernized, although in some areas the operations looked quite good. Although many machines in this plant appeared to be very old, they were still in very good condition, all were running, and the operators were very busy. About 40–50% of the workers were women.

The Krasny Proletariat makes turret lathes, vertical spindle machines, six-spindle semiautomatic lathes, camshaft and crankshaft machines, and other types of boring equipment. There we saw our first Russian conveyorized assembly line for machine tool construction. This continuous assembly line is used for assembling turret lathes. We were told the line has a production capacity of about 54 machines per day, and this figure is probably a fair statement of capacity. However, I am quite sure that it was not running at that rate on the day we were there. We also saw ceramic cutting tools used on experimental lathes which they claimed were operating at a surface speed of up to 900 meters per minute. They claimed they were producing about an 80 micro finish with these ceramic tools.

One of the most interesting areas of inquiry we investigated was the institute of Automechanics and Telemechanics where work is being done on three main lines of investigation:

1. The division of general theoretical problems.
2. The theory of digital systems.
3. The automation of industrial processes.

Under the division of general theoretical problems they are working on the theory of automatic control, telemechanics, and design. They pay considerable attention to the widest range of development problems, including nonlinear mechanical devices. They are also studying high-speed devices, instrument precision, and impulse-type systems. Analytical work often is accompanied by experimental work for purposes of verification. Recently work has been done on analog systems, both theoretically and experimentally.

The section on the theory of digital systems is working on a theory of relays. This includes Boolean algebra, application to measurement and control systems, and work on pneumatic, hydraulic, and electric systems, with some thought being given to contactless electrical systems. Some studies have been made on instruments for measurement in industrial control systems.

It appeared that most of the activities of the section on automation of industrial processes are of a consulting nature. I was told that most of the work is done in the factories of the nation, but that many questions submitted by the factories are answered in the laboratories under this section.

Perhaps the most interesting thing at the institute was the analog computer. It is possible that some of the theoretical work being done with the computer is rather good. However, it is nearly impossible to make a complete evaluation of a theoretical program when working through a nontechnical interpreter. It was our impression that they were doing better work in hydraulic and pneumatic servo systems than they were doing in electrical control systems; however, better work was done on both these types of systems in this country as long as seven or eight years ago. At the same time it should be remembered that the most advanced servo work in this country has been done in the military field, and if this is also true in Russia, we would not have had an opportunity to see it.

In the field of magnetic amplifiers, they seem to be behind us by some years, assuming that the work we saw at this institute is the best they are able to do.

Computer for Solving Scientific Problems

At the Institute of Precision Mechanics and Calculating Technology we saw one of the most impressive achievements of Soviet technology — the BESM computer. BESM are the Russian initials for a high-speed electronic machine intended for the

Russian Production Making Rapid Strides

continued

solution of scientific problems. It cannot, however, properly be considered as a machine competitive with the IBM-701 or the IBM-704.

This computer is a three-address machine with a floating decimal point. It carries five betts of information for command purposes and numbers up to 11 digits. It operates 24 hours per day at about 72% efficiency — test time amounts to about 20% and error loss to 8%. The staff estimated it has a production equivalent of about 12,000 human operators. It averages 7000–8000 arithmetical processes per second, while an experienced worker can do only about 2000 a day with an ordinary office adding machine. Thus, in a few hours it does calculations an experienced worker would not be able to do in the whole of his lifetime with manual equipment. We were told that in less than 20 hr the machine solved a problem containing 800 equations and calling for 250 million arithmetical processes. It is also capable of translating in several languages.

We saw the machine work out one rather novel problem in short order. Practically everywhere we went in Russia we saw chessboards set up with supervisory personnel playing chess in spare moments. Often men engaged in a game would make two or three moves, then leave the board set up, and return to the game later after attending to other duties. In this case two computer technicians playing chess were stymied over the next move. They wondered what the next move should be, looking four or five moves ahead. So they fed the chess problem into the machine and it quickly indicated the next move.

We saw automobile and tractor production lines in operation at the Gorki Automobile Plant and at the Stalingrad Tractor Plant. At neither place did we find production techniques comparable to those in this country, and at neither did we see much in the way of new processes.

The most complete application of automation on our itinerary was at the Kaganovich Ball Bearing Plant, the top bearing producing plant in the Soviet Union. This plant produces some 1300 types of bearings ranging from four ton bearings — made on special order only — to 150 gram bearings which are production items. A year's output is approximately 60 million bearings.

This plant had several lines, only one of which was completely automated. On the automated line, all operations are performed automatically, including the handling between processes, until the packaged bearing is ready for shipping. Hot rolled forgings are dumped into hoppers at the start of manufacture, then the parts proceed into automatic chuckers, through a series of processes — including heat-treat, grinding operations, final inspection, assembly, and test — and on into a packaging machine where the bearings are wrapped in oil paper and sealed in individual cardboard packages. The only operators on this line are the people who adjust and maintain the production equipment.

Since returning from my trip to Russia I have visited an automated bearing production line in this country. I was unable to watch the Russian line and the American line long enough to determine which is the more efficient, but from an engineering standpoint, the Russian line looked very good. Their plans call for approximately 30 automated bearing lines by 1960.

1958 SAE Journal Index Will Appear in December Issue

An Index of all technical articles published in the 1958 issues of SAE Journal will appear at the end of the December issue of the Journal. The Index will cover all material published in the Journal during 1958, based on the following:

1. Papers presented at National Meetings.
2. Papers presented at Section Meetings, received at SAE Headquarters.
3. Round table and production panel reports received at SAE Headquarters.
4. Articles based on SAE Advisory Committee reports.

Every article is indexed by:

1. Authors' names.
2. Journal headline.
3. Subject headings.

(When the Journal article contains discussion, the names of the discussers are also listed.)

Constitutional Amendments
Growing Out of
Planning for Progress Proposal

THE following proposed amendments to the SAE Constitution are being submitted to the voting members of the Society, "at least sixty days before the next Annual Business Meeting . . ." in accordance with C 54 of the Society's Constitution.

These proposed amendments and the explanatory comments thereon are the result of a review of the Constitution undertaken by the Constitution Committee at the request of the Council . . .

1) To provide for the Planning for Progress Committee's proposal for changing the Society's organization, as outlined in the October Journal;
2) To carry out Council's recommendations on Life Membership, Honorary Membership, Student Enrollment, Associate grade;
3) To make miscellaneous changes for clarification and to conform to current practices;
4) And to rearrange the sections of the Constitution for better sequence.

The recommendations of the Planning for Progress Committee and the Constitution Committee were endorsed by the Council at its September 7, 1958, meeting for submission to the voting members.

To provide for an orderly transition, assuming the membership approves the Constitutional amendments submitted herewith, it is planned to proceed as follows:

a. The present Society structure and its Officers would continue operating until the close of the 1959 administrative year under the present Constitution.
b. The new Society structure covered by the amended Constitution would be put into operation starting with the 1960 administrative year.
c. The nomination and election of Officers to take office at the start of the 1960 administrative year would be conducted under the present provisions of the Constitution. However, those nominated as Vice-Presidents for 1960 by the 1959 Activity Nominating Committees would be listed on the ballot for election of 1960 Officers as Directors, to serve on the Board of Directors for one year. Those nominated by the Annual Nominating Committee to serve as Councilors of the Society for the years 1960 and 1961 would be listed on the ballot for election of Officers as Directors for two-year terms (1960–1961) on the Board of Directors. The three Councilors elected to serve for 1959 and 1960 will continue as Directors for 1960.
d. For the transition year of 1960, the Board of Directors would, therefore, consist of:
   1 President
   1 Treasurer
   3 Directors for one year (formerly Councilors)
   3 Directors for two years (nominated as Councilors)
   12 Directors for one year (nominated as Vice-Presidents)
   2 Past-Presidents
   22
e. The nomination and election of Officers (including Directors) to take office at the start of the 1961 administrative year would be conducted under the Constitution as amended.

As required by the Constitution, the proposed amendments will be presented for discussion and final amendment at the Annual Business Meeting to be held in Detroit on Tuesday, January 13, 1959; and, if at that time twenty votes are cast in favor of such submission, the proposed amendments shall subsequently be submitted by letter ballot to all members entitled to vote.

Proposed Amendments

Deleted language is crossed out; proposed additions are underscored.

No explanation is included where amendment is merely to change section number and/or change "Council" to "Board of Directors."

Name, Object and Government

C 1 The title of this Society is "SOCIETY OF AUTOMOTIVE ENGINEERS, Inc."

C 2 The object of the Society is to promote the Arts, ~~and~~ Sciences, ~~and~~ Standards and Engineering Practices connected with the design, construction and utilization of ~~automotive apparatus, all forms of self-propelled or mechanically-propelled mediums for the transportation of passengers or freight, and internal combustion prime movers.~~ self-propelled mechanisms, prime movers, components thereof, and related equipment. ~~The principal means for this purpose shall be the holding of meetings for the reading and discussion of professional papers and reports, the publication and distribution of the same, and social intercourse.~~

Explanation: To bring the statement of the Society's object up to date, the above revisions in C 2 are recommended. Its division into C 2 and C 3 is also recommended. This makes C 2 a statement of the Society's object with the means of achieving this object covered in C 3.

C 3 The principal means for accomplishing this object shall be the holding of meetings for the presentation and discussion of professional papers, the development of technical reports including engineering standards and recommended practices, and the publication and distribution of same.

See explanation under C 2.

C 4 The Society shall be organized as a Membership Corporation under the laws of the State of New York. Its principal offices shall be located in the City of New York.

Explanation: For clarification.

~~C 3~~ C 5 The Society shall be governed by this Constitution and by By-Laws and Rules in harmony therewith.

~~The Council~~ Board of Directors

~~C 24~~ C 6 The affairs of the Society shall be managed by a Board of Directors chosen from among ~~its~~ the voting members~~,~~ of the Society. ~~which shall be styled the "Council."~~ The Board shall have the power to regulate its own proceedings. The ~~Council~~ Board of Directors shall consist of the President; ~~the Vice Presidents representing, one each respectively, the Professional Activities of the Society recognized by the Council and specified in the By-Laws; six Councilors;~~ the Treasurer; ~~and~~ the two surviving Past-Presidents who last held office~~.~~; and twenty-one Directors. One-third of the ~~number of voting~~ members of the ~~Council~~ Board of Directors shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations ~~of the Council~~, but shall not have a vote therein.

Explanation: This revision substitutes the term "Board of Directors" for Council. It also redefines the membership of the Board in accordance with the proposals of the Planning for Progress Committee. The words "which shall have the power to regulate its own proceedings" were in the current C 26 but preferably belong in this paragraph.

Vacancy in Board of Directors

~~C 35 Should a vacancy occur in the Council or in any elective office except the Presidency, through death, resignation or other cause, the Council may select a voting member of the Society to fill the unexpired term of the office which has become vacant. Should a vacancy occur in the Presidency, the Council shall select one of its number to fill the vacancy until the next annual election.~~

~~C 35~~ C 7 Should a vacancy occur in any elective office through death, resignation or other cause, the Board of Directors is empowered to fill the unexpired term of the office which has become vacant. The appointee shall be selected from among the voting members of the Society, and if the vacant office is the Presidency, the appointee shall be selected from among the members of the Board of Directors.

Explanation: According to Society's attorneys, the present language could be interpreted to mean that the Board of Directors can, but is not required to fill vacancies and that, if the Board does fill a vacancy, the appointee may or may not be a voting member of the Society. The new language is intended to make it clear that the Board has the power but is not required to fill vacancies, but that if it does fill a vacancy then the appointee must be a voting member of the Society except that in the case of the Presidency the appointee must be selected from the members of the Board. The exercising of the appointing power is made permissive because, if the vacancy develops late in the administrative year, no useful purpose might be served by filling the vacancy.

Vacating Offices

~~C 29~~ C 8 The ~~Council~~ Board of Directors may, by a two-thirds vote of ~~the~~ its members ~~present~~, declare any elective office vacant, on the failure of its incumbent for six months, from inability or otherwise, to attend ~~the Council~~ Board of Directors meetings, or to perform the duties of his office~~,~~. ~~and shall thereupon appoint a voting member to serve for the unexpired term of the office in which the vacancy occurs. The said appointment shall not render the appointee ineligible to election to any office.~~

Explanation: This revision is rec-

to the SAE Constitution

ommended to require a two-thirds vote of the entire membership of the Board of Directors to declare an elective office vacant rather than the present two-thirds of the members in attendance at the meeting. Deletion of the latter portion of the section is recommended because amended C 7 adequately covers filling vacancies.

~~Amendments to~~ By-Laws and Rules

~~C 55~~ **C 9** For the further ordering of the affairs of the Society the ~~Council~~ Board of Directors may, by a two-thirds vote of its members ~~present~~, adopt By-Laws or amend the By-Laws in harmony with this Constitution, provided that written notice of such proposed By-Law or By-Law amendment shall have been given at the previous regular meeting of the ~~Council~~ Board of Directors, and~~,~~ provided further~~,~~ that the Secretary shall have mailed to each member of the ~~Council~~ Board of Directors a copy of such proposed By-Law or By-Law amendment at least ten days in advance of the meeting of the ~~Council~~ Board of Directors at which action is to be taken. The By-Law or By-Law amendment shall take effect immediately on its passage by the ~~Council~~ Board of Directors, unless otherwise provided. Such By-Law or By-Law amendment shall be announced in the next ~~regular~~ issue of the official publication of the Society.

Explanation: The deletion of the word "present" is recommended to require a two-thirds vote of the entire Board of Directors.

The revision in the next to the last sentence is recommended to give the Board of Directors authority to set the effective date of a new By-Law or a revision in an existing one. With reference to the revision in the last sentence of the section, the next regular publication of the Society might be the Handbook or Transactions, for example. It is contemplated that the Board of Directors will adopt a By-Law making the SAE Journal the official publication of the Society. Hence, this revision in combination with the new By-Law will make it clear that By-Law amendments are to be announced in the Journal.

~~C 56~~ **C 10** The ~~Council~~ Board of Directors may, by a majority vote of the members present at any meeting, establish, amend, or annul Rules for the conduct of the business affairs of the Society~~;~~, for the ordering and conduct of its professional or business meetings~~;~~, and for the guidance of its committees in their work and reports — provided that such Rules are in harmony with the Constitution and By-Laws of the Society.

Meetings

~~C 36~~ **C 11** The Society shall hold an Annual Business Meeting. The Annual Business Meeting shall be held at such time and place as the ~~Council~~ Board of Directors may appoint. Fifty voting members shall constitute a quorum for the transaction of business.

~~C 37~~ **C 12** A Special Business Meeting of the Society may be called at any time at the discretion of the ~~Council~~ Board of Directors or shall be called by the President upon the written request of ten per cent of the voting membership, the notices for such meeting to state the business for which it is called; and no other business shall be entertained or transacted at such Special Business Meeting. Fifty voting members shall constitute a quorum for the transaction of business at Special Business Meetings.

Vote Required for Action

~~C 30~~ **C 13** Every question which shall come before a meeting of the Society or of the ~~Council~~ Board of Directors ~~or of a committee,~~ shall be decided by a majority of ~~the votes cast,~~ those present, unless otherwise provided in this Constitution or By-Laws, or the laws of the State of New York. The ~~Council~~ Board of Directors may order the submission of any question to the membership by letter ballot. Any meeting of the Society at which a quorum is present~~,~~ may order the submission of any question to the membership by letter ballot.

Explanation: The deletion of the words "or of a committee" is recommended because the Technical Board has rules, and other Boards and Committees may adopt rules, which require more than a bare majority vote to make action valid. If the Constitution were to remain as is, in the event that any question came up, the Constitutional provision would be controlling regardless of the committee's rules.

The Society's attorneys recommended that the paragraph be amended to require a majority of the votes of "those present" rather than "those cast" inasmuch as this is the legal requirement. The reason for this is that if most of those present decline to vote, one vote cast could be a majority. The majority meets the legal requirement in this instance.

~~Council's~~ Executive Committee of the Board of Directors

~~C 26~~ **C 14** The ~~Council~~ Board of Directors ~~shall regulate its own proceedings and~~ may by resolution delegate specific powers to an Executive Committee appointed from among its members or to any one or more members of the ~~Council~~ Board of Directors; provided that no act under such delegation of power shall be binding until it has been approved by resolution of the ~~Council~~ Board of Directors.

Explanation: The first clause in the first sentence of this paragraph does not deal with the Executive Committee. Hence, it has been transferred to amended C 6.

The insertion of "appointed from among its members" was to provide specifically that the Executive Committee shall be made up of members of the Board of Directors which has always been the practice.

Membership

~~C 13~~ **C 15** All ~~original~~ applications for election to membership shall be presented to the ~~Council~~ Board of Direc-

continued

Proposed Amendments to the SAE Constitution

Deleted language is crossed out; proposed additions are underscored.

No explanation is included where amendment is merely to change section number and/or change "Council" to "Board of Directors."

continued

tors, which shall consider and act upon each application, electing each applicant to the grade of membership to which, in its judgment, his qualifications entitle him. Two negative votes shall defeat the election of an applicant.

Explanation: Actually, original applications are not ordinarily submitted to the Board of Directors. The practice is to present them to the members of the Membership Grading Committee, which Committee in turn makes recommendations to the Board of Directors. The Society's attorneys suggested deletion of the word "original" to bring the Constitution in line with current practice.

~~C 12 Honorary Members shall be nominated by at least ten voting members of the Society. The grounds upon which the nomination is made shall be presented to the Council in writing. The election of Honorary Members shall be by a vote of the Council taken by letter ballot, as provided in the By-Laws. One dissenting vote shall defeat such election.~~

Explanation: Inasmuch as amended C 18 provides for awarding Honorary Membership to Past-Presidents only, C 12 outlining method of electing Honorary Members should be deleted.

~~C 5~~ C 16 The membership of the Society shall consist of Honorary Members, Members, Associates and Juniors.

~~C 6~~ C 17 Only Members and Honorary Members are entitled to hold office in the parent Society; and to vote on questions arising at any Business Meeting of the Society or which may be submitted for letter ballot, and on Constitutional amendments, and for Officers ~~and Councilors~~ of the Society~~,~~. ~~for delegates at large to the Annual Nominating Committee and for members of Activity Nominating Committees.~~ Members entitled to vote may vote by proxy given to another voting member, provided that such proxy shall not be valid for a greater time than six months.

Explanation: To delete reference to Activity Nominating Committees. Also deletion of requirement that "Only Members and Honorary Members are entitled to vote for delegates-at-large to the Annual Nominating Committee." Latter deletion was made because, under the new arrangement, one of the delegates-at-large is elected by the Sections Board and it is contemplated that membership on this Board will be open to all grades.

~~C 7 Honorary Members shall be persons of acknowledged professional eminence and their number shall not exceed one per cent of the total membership at the time of their election.~~

~~C 7~~ C 18 Honorary Member grade shall be confined to Past-Presidents of the Society. Past-Presidents shall be awarded Honorary Membership at the end of their second year's service on the Board of Directors as Past-Presidents.

Explanation: This revision carries out the recommendation of the Council that Past-Presidents be awarded Honorary Membership at the expiration of their second year's service on the Council, and that Honorary Membership be confined to Past-Presidents.

~~C 8~~ C 19 Member grade shall be composed of persons not less than 26 years of age ~~or over,~~ who by ~~previous~~ technical training, ~~or~~ experience, or ~~by present~~ occupation are qualified ~~to develop, design or supervise construction of complete automotive apparatus or any of its important component parts; or to exercise responsible technical supervision of the selection, research, development, production, processing or application of materials used in the construction or utilization of automotive apparatus; or to take~~ for responsible activity in: design, research, development, manufacture, application, operation, maintenance or technical instruction; as they relate to self-propelled mechanisms, prime movers, components thereof or related equipment, or materials used in the construction or utilization of such apparatus; ~~charge of automotive engineering work, including operation or maintenance; or to impart technical instruction in the development, design, construction and utilization of automotive apparatus;~~ or persons who by reason of distinguished service or noteworthy accomplishment would, in the discretion of the ~~Council~~ Board of Directors, appear to be desirable additions to this grade.

Explanation: At the suggestion of the Society's attorneys, this section has been modified to conform to C 2 of the proposed revision.

~~C 9~~ C 20 Associate grade shall be composed of persons not less than 26 years of age, who are not eligible for Member grade but who are qualified, by reason of position or experience, to cooperate technically with automotive engineers in automotive engineering work or who, in the opinion of the ~~Council~~ Board of Directors, will further the objective of the Society.

Explanation: This amendment was proposed by the Membership Grading Committee and endorsed by the 1954 SAE Council at its January 14, 1955 meeting. By setting a minimum age of 26 for Associate grade the amendment would provide for one Junior grade of membership (Junior) and two senior grades of membership (Member and Associate). Thus, all candidates under 26 years of age would be required to meet the qualifications for Junior grade of membership to be elected to membership in the Society. This would be in keeping with past practice, which has been to limit election to Associate grade to candidates who are 26 years of age or over and to consider candidates under 26 years of age only for election to Junior grade of membership.

~~C 10~~ C 21 Junior grade shall be composed of persons who at the time of election are under thirty-three years of age and qualified, by education or experience, or both, to fill subordinate engineering positions in the automotive or allied industries. A Junior member may upon reaching the age of twenty-six and shall upon reaching the age of thirty-three be transferred to Member or Associate grade in accordance with the decision of the ~~Council~~ Board of Directors as to which grade his qualifications entitle him.

~~C 14~~ C 22 Upon written request by the applicant, the ~~Council~~ Board of Directors ~~may~~ shall transfer a member from one grade to another, ~~providing~~ provided that evidence satisfactory ~~proof~~ to the Board of Directors is presented ~~to it~~ that said member is qualified for transfer to the other grade.

Explanation: The change to read, "shall transfer", instead of, "may transfer", is recommended on the basis that if a member supplies satisfactory proof of qualification for a different grade, "shall" makes it obligatory for the Board of Directors to approve the transfer.

~~C 11~~ C 23 The rights and privileges of every member shall be personal to himself and shall not be transferable by his own act or by operation of law, except by the use of proxies as provided in section ~~C 6~~ C 17.

~~C 22~~ C 24 The ~~Council~~ Board of Directors may, ~~expel any member of any grade who in its opinion~~ by a three-~~quarters~~ fourths vote of its ~~duly elected~~ members, expel any member of any grade who in its opinion has violated the Constitution, By-Laws or Rules of the Society or has been guilty of conduct rendering him unfit to continue in the membership of the Society~~;~~, provided that in all such cases the member shall have been given written notice of the charges and an opportunity to defend himself.

Explanation: For clarification.

Initiation Fees and Annual Dues

~~C 16~~ C 25 The ~~Council~~ Board of Directors may, at its discretion, by a three-fourths ballot vote of its ~~duly elected~~ members, change any then existing schedule of initiation fees for membership. Such schedule may provide for the payment of initiation fees in installments. No increase in fees shall be effective until after two months' notice by ~~publication in the JOURNAL~~ announcement in the official publication of the Society or by letter to the membership.

Explanation: It is recommended that all references to the Journal be deleted from the Constitution. This will allow for simpler handling of amendments in the event the Journal name should be changed at some future date. It is contemplated that a By-Law will be adopted designating the Journal as the official publication of the Society.

~~C 17~~ C 26 The ~~Council~~ Board of Directors may, at its discretion, by a three-fourths ballot vote of its ~~duly elected~~ members, change any then existing schedule of dues for membership, and may provide for the payment of dues in installments. No increase in dues shall be effective unless announced ~~by publication~~ in the official publication ~~JOURNAL~~ of the Society, or by letter to the membership, at least one month prior to the beginning of the period in which the increase is to be first effective.

See comments under C 25.

~~Life Members~~

~~C 18 The Council shall have the power, by letter ballot, to admit to life membership, without the payment of a life membership fee, any person who, for a long term of years, has been a member when, for special reasons, such procedure would, in its judgment, promote the best interests of the Society, provided that notice of such proposed action shall have been given at a previous meeting of the Council. One dissenting vote shall defeat such admission.~~

Explanation: To delete reference to life membership in the Constitution since this is not a grade of membership but merely a method of dues payment.

~~C 19 Past-Presidents of the Society shall be awarded life membership, without payment of a life membership fee, at the end of their second year's service on the Council as Past-President.~~

Explanation: Proposed amended C 18 provides for awarding Honorary Membership to Past-Presidents.

~~C 15~~ C 27 Excepting Honorary Members ~~elected under C 12 and life members admitted under the provisions of C 18 and C 19~~, each member elected shall make payment in accordance with currently effective schedules of dues and initiation fees before becoming entitled to the rights and privileges of membership. If payments are not made in accordance with these requirements within three months after notice of election, the election becomes void.

Explanation: To delete reference to life membership and election to Honorary Membership, to carry out Council action recommending limiting Honorary Membership to Past-Presidents and clarifying payment of dues for life as a method of dues payment rather than a grade of membership.

Suspensions and Expulsions

~~C 20~~ C 28 Any member~~,~~ who is delinquent in the payment of annual dues for three months~~,~~ shall not be entitled to receive any publications or other services of the Society until such dues are paid. Any voting member~~,~~ who is delinquent in the payment of annual dues for three months~~,~~ shall not be entitled to vote or hold office as provided in section ~~C 6~~ C 17, or to serve on the Annual~~,~~ Nominating Committee, the Nominating Committees of the three Boards ~~Professional Activity~~ or Special Nominating Committees until such dues are paid. Any member who shall leave dues unpaid for one year shall, in the discretion of the ~~Council~~ Board of Directors, cease to have any further rights in the Society and be stricken from the rolls of membership. The resignation of a member can be accepted only by vote of the ~~Council~~ Board of Directors.

Explanation: To delete reference to Professional Activities, change name of Council and provide for Board Nominating Committees.

~~C 21~~ C 29 The ~~Council~~ Board of Directors may temporarily suspend the payment of dues by a member of any grade whose circumstances have become such as to make it a hardship for him to pay the dues, and under similar circumstances may waive the whole or part of dues in arrears. Such action shall be taken only upon submission of evidence satisfactory to the ~~Council~~ Board of Directors that the action is for the best interests of the Society. Any member whose dues have been suspended shall have Reserve Status and during the period of such suspension shall not be entitled to receive the publications or other services of the Society, or to vote or hold office as provided in section ~~C 6~~ C 17, or to serve on the Annual~~,~~ Nominating Committee, the Nominating Committees of the three Boards ~~Professional Activity~~ or Special Nominating Committees.

Explanation: To delete reference to Professional Activities, change name of Council and provide for Board Nominating Committees.

Dues Not Returnable

~~C 23~~ C 30 Members of any grade shall not be entitled to any return of fees or dues upon severing their connection with the Society.

~~Professional Activity Committees~~

~~C 43 A professional activity may, in the discretion of the Council, be recognized by authorizing the establishment of a committee of voting members to represent the members of the Society interested in the activity, for purposes which are in harmony with the object of the Society. Not less than 80 per cent of the members of a committee so recognized shall be voting members of the Society. Such an activity so recognized shall be known as a Professional Activity; and when so recognized shall be listed in the By-Laws. It shall have such powers and act under such rules and regulations as the Council may from time to time prescribe.~~

~~Each Professional Activity so recognized shall be represented on the Council of the Society by a duly elected Vice-President, who shall be Chairman of the Committee of the Professional Activity he represents.~~

Explanation: Deletion of this section is recommended to eliminate reference to the Professional Activity Committees.

continued

Proposed Amendments to the SAE Constitution

Deleted language is crossed out; proposed additions are underscored.

No explanation is included where amendment is merely to change section number and/or change "Council" to "Board of Directors."

continued

Boards

C 31 The President, with the approval of the Board of Directors, shall appoint an Engineering Activity Board to develop, collect and distribute technical information of value to members of the Society; a Technical Board to promote and supervise cooperative technical committee activities; and a Sections Board to supervise and coordinate the activities of the local units and Enrolled Students of the Society.

The Board of Directors shall define, by By-Laws or otherwise, the organization, scope and authority of these three Boards. The Chairman of each of the three Boards may attend meetings of the Board of Directors and take part in discussions affecting the work of his Board but shall not have a vote.

Explanation: This new section is recommended to provide for the Technical Board and the new Engineering Activity and Sections Boards.

Standing Committees

~~C 40~~ C 32 The President, with ~~Council~~ Board of Directors approval, may appoint such committees as ~~Council~~ the Board of Directors may find necessary to assist it in the discharge of its responsibilities. The ~~Council~~ Board of Directors may define, by By-Laws or otherwise, the scope and authority of such committees. The chairman of each such committee~~s~~ may attend the meetings of the ~~Council~~ Board of Directors and take part in the discussion of questions affecting ~~their~~ the work of his committee~~s~~, but shall not have a vote.

Duties of Committees

~~C 46~~ C 33 All committees of the Society shall perform the duties required of them by the By-Laws~~,~~ or assigned to them by the ~~Council~~ Board of Directors. The President and the Secretary of the Society shall, ex officio, be members of all the committees and subdivisions thereof. Any proposed ~~expenses~~ expenditures of Society funds ~~of~~ by such committees must be authorized by the ~~Council~~ Board of Directors before they are incurred.

Removal of Committee Members

~~C 47~~ C 34 The ~~Council~~ Board of Directors may at any time, ~~in its discretion,~~ by a two-thirds vote of its members, remove any or all members of any committee or appointed Board, except ~~of an~~ the Annual Nominating Committee, ~~Professional Activity Nominating Committee,~~ the Nominating Committees of the three Boards, Special Nominating Committees, or the Past-Presidents' Advisory Committee; and the vacancy, arising from this or from any other cause, shall be filled by appointment by the President~~.~~, subject to approval of the Board of Directors.

Explanation: The revisions in this section are recommended to require that two-thirds of the Board of Directors approve the removal and also to make it consistent with the new section C 46.

Past-Presidents' Advisory Committee

~~C 45~~ C 35 The Past-Presidents of the Society shall constitute the Past-Presidents' Advisory Committee. This Committee shall meet once during the Annual Meeting and at such other times and places as it may elect. This Committee shall provide for its own organization. The Committee may consider any matter referred to it by the ~~Council~~ Board of Directors, or any other matter which in its opinion concerns the interests of the Society. The Committee may report its recommendations directly to the ~~Council~~ Board of Directors, or directly to the membership of the Society when such recommendations have the approval of a majority of the full membership of the Committee.

Local Units

~~C 48~~ C 36 The ~~Council~~ Board of Directors may, in its discretion, authorize the organizing of local units of the Society of any or all grades of membership, for purposes which are in harmony with the object of the Society. Such units shall be designated as SAE Sections or SAE Groups and shall have such powers and shall conform to such rules and regulations as the ~~Council~~ Board of Directors may from time to time prescribe.

Student Enrollment

~~C 49~~ C 37 The ~~Council~~ Board of Directors may further, in its discretion, authorize the enrollment~~, individually or by group,~~ of persons ~~under 30 years of age,~~ who, at the time of application, shall be bona-fide students taking engineering or allied courses at ~~of a~~ recognized institutions of learning. ~~engineering or pursuing an approved course of study in automotive engineering. Student Enrollment may be for the duration of the student's recognized or approved course plus one year thereafter. The Council may establish the maximum period for which a student may be enrolled.~~ The ~~Council~~ Board of Directors shall determine the amount of the annual enrollment fee. Enrolled Students shall not be members of the Society.

Explanation: This revision is recommended to provide needed flexibility in handling the changing conditions connected with Student Enrollment. In connection with this revision it is anticipated that the following By-Law will be adopted:

B — Student Enrollment may be for ~~the duration of the student's recognized or approved course plus one year thereafter,~~ six years while an undergraduate, plus an additional two years while a graduate student. The ~~Council~~ Board of Directors may extend the period of enrollment for students entering military service before or immediately after graduation. ~~establish the maximum period for which a student may be enrolled.~~

Annual Report

~~C 27~~ C 38 The ~~Council~~ Board of Directors shall present ~~at the Annual Business Meeting of the Society,~~ a report~~,~~ at the Annual Business Meeting of the Society, verified by the President and Treasurer or by a majority of the members of the ~~Council~~ Board of Directors, showing the whole amount of real and personal property owned by the Society, where located, and where and how invested, and the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition; the amount applied, appropriated or expended during the year immediately preceding such date, and the purposes, objects or persons to or for which such applications, appropriations, or expenditures have been made; also the names and places of residence of the persons who have been admitted into membership in the Society during the last year; which report shall be filed with the records of the Society, and an abstract thereof shall be entered in the minutes of the proceedings of the Annual Business Meeting.

Officers

~~C 28~~ C 39 Each year the following Officers of the Society shall be elected from among the voting members:

A President, to hold office for one year.

~~As many Vice-Presidents, each to~~

~~hold office for one year, as there are recognized Professional Activities of the Society specified in the By-Laws.~~

Seven Directors ~~Three Councilors,~~ each to hold office for ~~two~~ three years. In the first election of Officers after this paragraph becomes effective, eighteen Directors shall be elected from among the voting members. Seven of these Directors shall be elected to serve three-year terms, seven shall be elected to serve two-year terms and four shall be elected to serve one-year terms.

A Treasurer, to hold office for one year.

Explanation: To delete reference to Vice-Presidents and to provide for the election of a Board of Directors on the new basis.

(NOTE: At the time this section becomes effective, there will be three Councilors under the present section C 30 who will have one more year to serve. Hence, it would be necessary to elect only four Directors for one-year terms in the first election and have the three Councilors serve as Directors for one year.)

~~C 31~~ C 40 The election of Officers shall be by sealed letter-ballot, as the By-Laws shall provide.

~~C 32~~ C 41 The term of all elective Officers shall begin on the adjournment of the Annual Business Meeting of the Society. Officers shall continue in their respective offices until their successors shall have been elected and accepted their offices.

~~C 33~~ C 42 ~~A~~ The President, ~~a Vice-President~~ or any other voting member of the ~~Council~~ Board of Directors, except the Treasurer, shall not be eligible for immediate re-election to the same office at the expiration of the term for which he was elected.

Explanation: To delete reference to Vice-Presidents and change name of Council to Board of Directors.

Secretary

~~C 34~~ C 43 The ~~Council~~ Board of Directors, at its first meeting after the Annual Business Meeting of the Society, shall appoint a voting member to serve as Secretary of the Society for one year, subject to removal for cause by a majority vote of the duly elected members of the ~~Council~~ Board of Directors, at any time after one month's written notice has been given him to show cause why he should not be removed, and he has been heard in his own defense, if he so desires. The Secretary shall receive a salary which shall be fixed by the ~~Council~~ Board of Directors at the time of his appointment.

Duties of President, Secretary and Treasurer

~~C 35~~ C 44 The President, Secretary and Treasurer shall perform the duties legally or customarily attaching to their respective offices under the laws of the State of New York, and such other duties as may be required of them by the ~~Council~~ Board of Directors.

Annual Nominating Committee

~~C 41~~ C 45 The Annual Nominating Committee of the Society shall consist of ~~three~~ six delegates-at-large, and one delegate from each geographical Section of the Society. ~~No two of the delegates-at-large shall reside in the same Section district.~~ The delegates-at-large shall be elected ~~by the voting members present at the Annual Business Meeting,~~ as follows:

Three by the Past-Presidents' Advisory Committee.

One each by the Engineering Activity Board, the Technical Board, and the Sections Board.

The Section delegates shall be elected by and from each Section. ~~prior to the Annual Business Meeting of the Society.~~ Each Section and Board may elect, in addition to a delegate, a first alternate and a second alternate. The first alternate shall serve in the absence of the delegate, and the second alternate shall serve in the absence of both the delegate and the first alternate. All delegates and alternates to this Commitee shall be voting members of the Society. Neither a delegate nor an alternate may be represented by a proxy at a meeting of the Nominating Committee.

The names of all delegates and alternates shall be submitted to the Secretary not later than the date established in the By-Laws.

The work and procedure of the Committee shall be as defined in the By-Laws.

The Annual Nominating Committee shall select nominees for President, Treasurer and four Directors. In the nominations for the first election of Officers after paragraph C 39 becomes effective, the Committee shall select nine nominees for Directors; one to serve for a term of one year, four to serve two-year terms, and four to serve three-year terms.

Explanation: Revisions in this section are recommended to eliminate election of three delegates-at-large at the Annual Business Meeting, and to provide for the addition of delegates-at-large selected by the Past-Presidents' Advisory Committee, Engineering Activity Board, Technical Board and the Sections Board.

(NOTE: At the time this section becomes effective, there will be three Councilors under the present C 30 who will have one more year to serve. Therefore, it will be necessary for the Annual Nominating Committee to elect only one Director for a one-year term in the first election held after this amendment becomes effective.)

Professional Activity Nominating Committees

~~C 44 In the inaugural year of any Professional Activity, its Vice-President shall be nominated by a Nominating Committee consisting of seven voting members, elected at a meeting of the Committee representing the Professional Activity concerned. Not more than two of the seven members elected shall be chosen from any one Section of the Society.~~

~~During each subsequent year of a Professional Activity, its Vice-President shall be nominated by a Nominating Committee consisting of seven voting members, two to be elected by the Professional Activity Committee and the remaining five elected at a stated Business Session of the Professional Activity which he is to represent. Not more than two of the seven members elected shall be chosen from any one Section of the Society.~~

~~Twenty or more members entitled to vote may constitute themselves a Special Nominating Committee of a Professional Activity, with the same power as that of the annual Nominating Committee of its Activity.~~

~~Members of Professional Activity Nominating Committees may not be represented by proxy at meetings of such committees. The work and procedure of Professional Activity Nominating Committees shall be defined in the By-Laws.~~

Explanation: Deletion of this section is recommended to eliminate reference to the Professional Activity Nominating Committees.

Board Nominating Committees

C 46 Each year the Engineering Activity Board, the Technical Board and the Sections Board shall each elect from its own members a Nominating Committee of voting members, and each of these Nominating Committees shall select one nominee for the Board of Directors. In the nominations for the first election of Officers after paragraph C 39 becomes effective, the members of each Nominating Committee shall select three nominees; one to serve a one-year term, one to serve a two-year term and one to serve a three-year term.

Members of these Nominating Committees may not be represented by

continued

Proposed Amendments to the SAE Constitution

Deleted language is crossed out; proposed additions are underscored.

No explanation is included where amendment is merely to change section number and/or change "Council" to "Board of Directors."

continued

proxy at meetings of such Committees. The work and procedure of these Nominating Committees shall be as defined in the By-Laws.

Explanation: This new section is recommended to provide for the nomination of three Directors, one by the Engineering Activity Board, one by the Technical Board and one by the Sections Board.

It will be noted that the membership of the Board Nominating Committees is restricted to "voting members." This is in harmony with the spirit of the present Constitution where both the Annual and Professional Activity Nominating Committees are restricted to voting members.

~~C 48~~ C 47 Twenty or more members entitled to vote may constitute themselves a Special Nominating Committee with the same power as the Annual Nominating Committee or any other Nominating Committee.

Explanation: "or any other Nominating Committee" is added to cover the Nominating Committees of the three Boards.

Publications

~~C 50~~ C 48 ~~The official record of~~ Papers, reports, ~~and~~ discussions and other literature of interest to the Society shall be published and distributed as the ~~Council~~ Board of Directors may direct. ~~The public shall have free access to the library of the Society, under such regulations as the Council may formulate.~~

Explanation: The reference to the library of the Society is deleted because the Society does not have a library. It is felt that the main intent is to make SAE material freely available to everybody and that this intent is set forth in the first sentence of C 49 as amended.

~~C 51~~ C 49 ~~The Society shall claim no exclusive copyright to any paper read at its meetings, or any discussions thereon.~~ The policy of the Society shall be to give the papers read before its meetings and the reports adopted ~~at its meetings~~ by its Committees wide circulation, with a view to making the work of the Society known, encouraging engineering progress, fulfilling the Society's object and extending the professional reputation of its members.

Explanation: It is recommended that the first sentence of present C 51 be deleted because experience has shown that it does not provide a practical guide.

~~C 52~~ C 50 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings. Matters relating to politics or ~~purely~~ to ~~trade~~ commercial considerations~~,~~ or not relating to the Society's object as defined in C 2~~,~~ shall not be discussed at a meeting of the Society, or be included in the editorial columns of its publications.

Explanation: For clarification.

Standards and Formulas

~~C 53~~ C 51 The Society may approve or adopt any standard, formula or engineering practice, but shall not approve any engineering or commercial enterprise. It shall not consent to the use of its name or initials in any commercial work or business, except to indicate conformity with its standards or recommended practices.

The right to use the Society emblem shall not be granted to any but members and then only for Society purposes.

Amendments to the Constitution

~~C 54~~ C 52 An amendment to this Constitution may be proposed by a majority vote of the ~~Council~~ Board of Directors obtained either at a ~~Council~~ Board of Directors meeting or by letter ballot of the ~~Council~~ Board of Directors taken at the request of the President, or by any voting member who secures authorization. Authorization of a voting member to propose an amendment shall consist of a petition in which the amendment is set forth bearing the signatures of twenty voting members. The proposed amendment, accompanied by any comment the ~~Council~~ Board of Directors wishes to make, shall be mailed by the Secretary to each member of the Society entitled to vote~~,~~ or shall be printed in the official publication of the Society at least sixty days before the next Annual Business Meeting~~,~~ or the next Special Business Meeting called for the purpose of amending the Constitution of the Society. At this Business Meeting such proposed amendment shall be presented for discussion and final amendment, and shall subsequently be submitted by letter ballot to all members entitled to vote, provided that twenty votes are cast in favor of such submission. The letter ballot, accompanied by the text of the proposed amendment, shall be mailed by the Secretary to each member entitled to vote, promptly after the close of said meeting. Ballots returned within thirty days after the date on which they are mailed to the voting membership shall be counted by Tellers appointed as provided by the By-Laws. The Tellers shall announce immediately the result of the vote, which shall be mailed to the members by the Secretary. The adoption of the amendment shall be decided by a majority of the votes cast.

An amendment shall take effect immediately upon the announcement of its adoption~~.~~, unless otherwise provided at the time the amendment is presented to the members.

Explanation: The provision for printing the amendments in the official publication of the Society is recommended so that the Constitution will conform with current practices of transmittal of proposed Constitutional amendments to the members of the Society.

It is also felt that some provision should be made for amendments to take effect as of some future specific date, rather than to make it mandatory for all amendments to become effective immediately upon announcement.

~~Implied Sanction~~

~~C 38 An act of the Council which shall have received the expressed or implied sanction of the membership at any subsequent meeting of the Society, shall be deemed to be the act of the Society, and shall not afterwards be impeached by any member.~~

Explanation: The Society's attorneys recommend deletion of this action as unnecessary since the Council each year has submitted and, in the future, the Board of Directors will submit a report on the Society's activities during the year for approval at the Annual Business Meeting.

~~Appropriations~~

~~C 38 Any appropriation recommended by the Society at a meeting, shall not take effect until it shall have been approved by the Council.~~

Explanation: The deletion of this section is recommended because it is questionable that the Council could legally exercise the authority it grants.

What's Ahead for

Piloted Flight Control Systems

Based on a report by

L. W. Strobel, Autonetics Division,

North American Aviation, Inc.

The following report was made at a regular meeting of Committee A-6, Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment. Such reports represent one aspect of SAE's Cooperative Engineering Program.

AS performance requirements for piloted aircraft continue to climb, the necessity for further integration of airframe and flight control system has become an unavoidable fact. Since alleviation of body bending requires a servo response that is three times the highest bending frequency, conventional fluid-powered servos do not always provide what is needed.

In view of this, future trends and concepts of fluid-powered flight control systems are related to servos, fluids, components, and test procedures in the following:

As a starting point, a conventional manual input servo is shown in Fig. 1. Of the many varieties of position feedback possible, the moving valve method is shown for schematic simplicity.

Introduction of electronic signal inputs has in the past been accomplished with series or parallel servos, as shown in Figs. 2 and 3.

These are familiar techniques, and it should be sufficient to point out that the prime advantage of *a series servo* is that motion of the series servo is not reflected at the pilot's stick. The prime disadvantage is that in the event of failure of the series servo, it must be centered and locked.

On the other hand, the prime advantage of *a parallel servo* is that in the event of failure, it need only be declutched, or put into free wheeling. The disadvantage is that all servo motions are reflected at the pilot's stick. If a portion of the electronic input signal is for stability augmentation, the constant jittering of the stick can be disconcerting to the pilot.

A solution to this problem is the

Continued on next page.

Muscles Controlling Flight Path

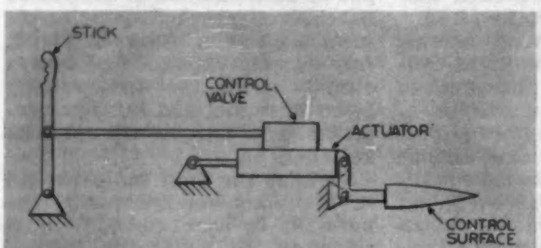


FIG. 1 MANUAL INPUT SERVO

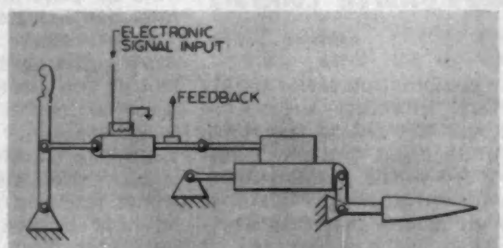


FIG. 2 SERIES INPUT SERVO

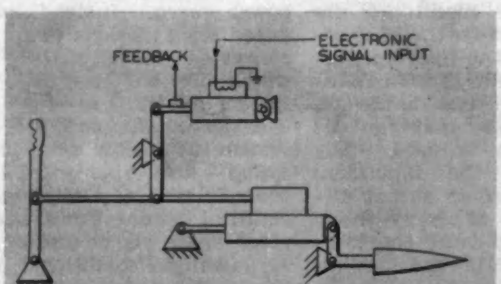


FIG. 3 PARALLEL INPUT SERVO

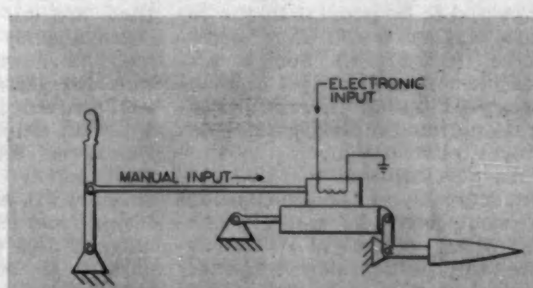
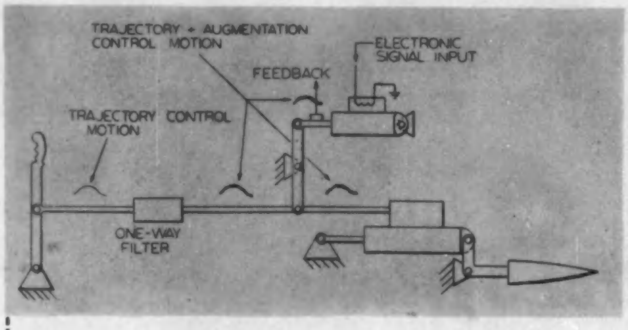


FIG. 4 DUAL INPUT VALVE SYSTEM



Servo Systems

Figure 5 — Development of a one-way filter apparatus would permit slow trajectory control motion to be reflected to the pilot's stick, but would filter out the higher-frequency stability augmentation motions. The one-way aspect would enable all pilot-initiated stick motions to be reflected to the servo.

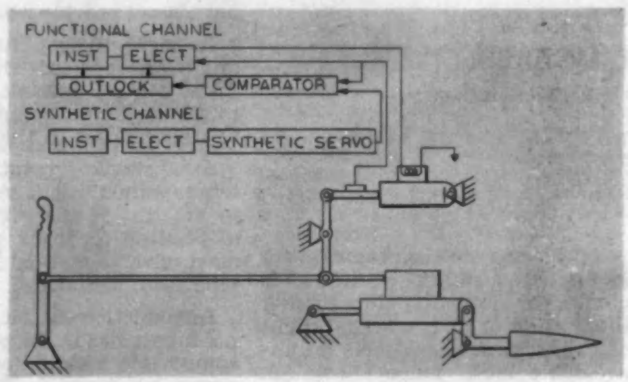


Figure 6 — In a synthetic monitoring system, the functional channel performs the work of trajectory control. All functions to be monitored are reproduced by the synthetic channel. Any malfunction in the functional channel would cause an output differing from that of the synthetic channel. This would cause the comparator to actuate the outlock mechanisms.

Trends
In Fluid-Powered Controls

continued ....

use of a combination series-parallel system. Stability augmentation signals are fed to the series servo while flight trajectory signals are fed to the parallel servo. This solution, although effective, suffers all of the penalties associated with the compounding of hardware.

A newer approach, which can be expected to be popular in the future, employs a *dual-input servovalve.* (See Fig. 4.) Such a valve accepts either electrical or manual signal inputs. A variety of operational modes are possible with proper valve design.

Another solution to this problem depends on the development of what might be called a one-way filter. (See Fig. 5.) This device will permit slow trajectory control motion to be reflected to the pilot's stick, but will filter out the higher-frequency stability augmentation motions. The one-way aspect is required in order that all pilot-initiated stick motions are reflected to the servo.

As the servo systems assume more authority in the flight control of the aircraft, the effect of servo malfunctioning will be of more concern. Monitoring provides one solution. One scheme employs what might be called synthetic monitoring. (See Fig. 6.) In this system, the functional channel performs the work of trajectory control. All of the functions of the functional channel that are to be monitored are reproduced by the synthetic channel. As shown, the instrumentation and electronics of each channel contain identical hardware, while an electronic analog of the functional servo is used. Any malfunction in the functional channel will cause an output differing from that of the synthetic channel and will cause the comparator to actuate the outlock mechanisms.

The extreme of this concept is the dual monitor system. Two complete functional channels are provided, and the mechanical output of each channel is monitored for discrepancy by an arrangement such as is shown in Fig. 7. Any discrepancy in the servo's output will cause the walking beam to rotate, and sufficient rotation will trigger the outlock switches.

Perhaps the most radical trend in flight control systems is the *pure fly-by-wire concept* illustrated in Fig. 8. In this system, there is no mechanical connection between the pilot's stick and the power servo. Instead, pilot-induced stick motions or forces are converted to electrical signals which are fed into the control system electronics.

A partial approach to such a system is found in what has been called an *augmented-latitude control system.* Although mechanical connections are provided, these will be declutched for various flight conditions. For example, if a flight program carries the aircraft through a range of

ns

of the Future

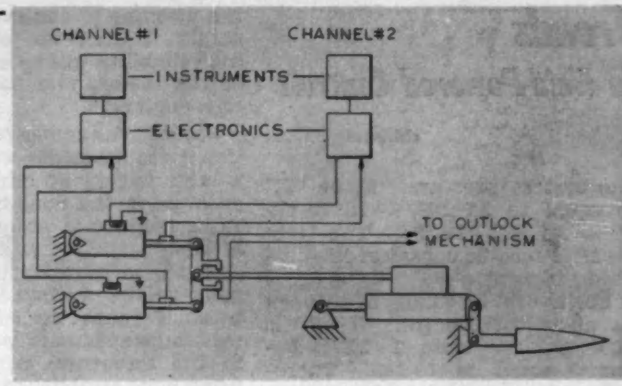


Figure 7 — A dual monitor system requires two complete functional channels. The mechanical output of each channel is monitored for discrepancy by the arrangement shown. Any discrepancy in the servo's output would cause the walking beam to rotate, and sufficient rotation would trigger the outlock switches.

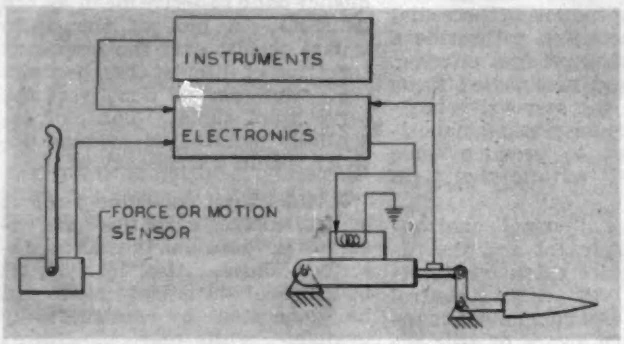


Figure 8 — The most radical trend in flight control systems is the pure fly-by-wire concepts. Here, there is no mechanical connection between the pilot's stick and the power servo. Instead, pilot-induced stick motions or forces are converted to electrical signals which are fed into the control system electronics.

flight conditions too broad for the pilot's ability to compensate, the mechanical linkage is declutched and latitude control is effected as follows: stick force is converted to an electrical signal and compared to the output of a normal accelerometer. The difference controls the elevator servo to a position such that actual normal acceleration is equal to stick-command normal acceleration. A large variety of arrangements are, of course, possible. Certainly, inhabited orbital vehicles of the future will have a great many fly-by-wire flight control functions.

Fluids of the Future

High-performance fluid-powered controls have conventionally used hydraulic fluids as a power transmission media. The choice has obviously been made on the basis of the properties of low compressibility and reasonable lubricity. However, when aircraft speeds increase or nuclear power plants are used, the fluids will undergo thermal and atomic degradation. It is a simple matter to predict that in several years conventional fluids, such as MIL-O-5606, will be obsolete for use in high-performance aircraft.

Today, temperature-resistant fluids are being developed, and usable fluids having 400 F capabilities with restricted service are available. Laboratory work is being done at the 700 F and even the 1000 F levels. Several fluids which exhibit temperature capability also exhibit good radiation resistance. In addition, the deleterious effects of fluid breakdown under radiation, namely outgassing and sedimentation, can be relieved to some extent with degassing and filtration equipment, just as fluids can be protected from thermal environments with cooling equipment. There is a weight and reliability limit imposed by such techniques, however, and in many future applications hydraulic fluids will not be suitable power media. In these cases, a solution might be found by using pneumatically powered flight control systems. Pneumatic control systems have been used in the past, but usually only in nominal-force, low-response systems.

Applications of the future can be expected to present all of the headaches associated with pneumatic servos. The predominate problem area can be described very easily.

If "A" is the area of an actuator, "R" is the moment arm, "V" is the actuator and chamber volume, and "B" is the bulk modulus, then the term: $2A^2R^2B/V$ represents the stiffness of the actuator. When the dynamics of the servo load are considered, this stiffness is added to the springlike portion of the load, "H," to form the total effective spring instant, "K," of the load-actuator combination. Then if "J" is the load inertia, the load actuator natural frequency is given by $\sqrt{K/J}$.

The effect of the pneumatic system compliance can be shown by considering an actuator designed to handle a load which is primarily springlike in nature. In this case, the term $2A^2R^2B/V$ reduces to $2BH/P$, where "P" is

Continued on next page.

Trends
In Fluid-Powered Controls

continued . . . .

the system pressure. Since "K" is equal to $2A^2R^2B/V+H$, it reduces to $H(1+2B/P)$. The term $1+2B/P$ may be considered a stiffening factor.

For hydraulic fluids "B" is taken as about 200,000 psi. If "P" is 4000 psi the term $1+2B/P$ becomes equal to $1+100$. Therefore, the system has been stiffened by a factor of 100 and the load natural frequency has been increased by the square root of 100, or 10.

On the other hand, if a 4000 psi gas system is used, the value of "B" will be about 2000 and the factor $1+2B/P$ will only be equal to $1+1$. Consequently the stiffness is only doubled and the load natural frequency is increased by the square root of 2, or about 1.4.

This demonstration perhaps is academic and is necessarily brief, but it does show that the stiffening effect of the actuator can be virtually lost when one resorts to a pneumatic power medium. Several solutions are possible. The simplest but most limited, constitutes an oversizing of the actuator. In other cases, the small end chamber volume of a pneumatic motor can be utilized to advantage. A third method employs additional feedback terms to provide synthetic stiffening. In general, the use of pneumatic servos will require a rather extensive dynamic study to ensure suitable performance. In addition, rather elaborate equalization techniques will be required to achieve this performance.

Components of the Future

Trends in flight control components may be drawn as natural conclusions of the preceding discussions.

First: In the future, mission success and pilot safety will depend to a greater extent upon the proper functioning of the flight control system. Thus, flight control components must be more reliable than ever. Because of the continual introduction of new hardware to perform new functions, standardization techniques will provide little, if any, help in the attempt to achieve high reliability. Rather, the job of attaining reliability will be in the hands of the system and hardware design engineers.

Second: A number of new functional requirements will generate a large variety of hardware. An example is the dual input servovalve mentioned before. Several of these valves are available today, and it is to be expected that even more will be available in the future. Perhaps the most significant advancements will be made in the servovalve field. Several firms have established a flow control valve as a first-line product and are now exploring potential product exploitation to provide a more diversified product offering. New firms and established firms are entering the servovalve business, and the resultant competition promises to produce some very decided advancements in this field.

Third: The thermal environment of the present and the future will require extensive development of all flight control components. All component manufacturers are aware of this requirement, and the product developments of tomorrow can be expected to be most impressive.

Fourth: A growing interest in high-performance pneumatic servos has opened up a new field of flight control components. Several firms have hot gas valves in the laboratory stage, and they expect to offer a valve to the market within 1 or 2 years. Solid-propellant gas generators, hot gas motors, and hot gas turbines are being tailored to flight control system requirements.

Future Testing Procedures

Radically new environments, functional requirements, and duty cycles have, in many cases, made existing testing specifications obsolete.

Efforts should be made to classify systems into sensible ranges of thermal and radiation levels. Blanket duty cycles must be replaced with a definite system that is not so severe as to obviate usable designs.

One such technique employs a statistical approach based on the fact that the overall duty cycle of a servo can be defined by the power spectral density of the serve signal input. A working comprehension can be developed with the following thinking.

The input to a servo actuator can be considered to consist of a random combination of reversals of various frequencies and amplitudes. Because of the reversals, the time-wise average of motion is zero, and, therefore meaningless. Consequently the amplitude of motion is squared and averaged over a series of narrow frequency bands. The mean square amplitudes thus derived are then divided by the width of the frequency band to derive mean square densities. A plot of the mean square density over the frequency spectrum of interest then becomes the power spectral density of the servo input signal. The plot essentially defines the average activity within a frequency band.

NACA efforts to define aircraft control surface activities have resulted in data in the form described above. Also, test signals of identical statistical nature can be generated by commercially available white-nose generators in conjunction with simple, passive filter networks. Any company with a reasonable analog computer facility can prepare calibrated tape recordings of any desired power spectral density.

Unfortunately, the number of test samples required to establish a high confidence level is almost prohibitive. Therefore, new techniques for predicting and validating reliability figures must be developed.

In brief, mean times to failure for parts such as resistors, capacitors, and transistors are determined from tests conducted on large-sample quantities to ensure a high confidence level. Then, the mean time to failure of a component consisting of a variety of these parts can be calculated by certain statistical methods.

It is doubtful that this technique can be applied directly to fluid-powered control components. However, some modification might be practical. To predict just what reliability techniques will be applied to fluid components would be difficult. But ever increasing reliability requirements seem to demand that meaningful techniques be developed.

Coming Soon

Do-It-Yourself VIBRATION Manual

Based on paper by

Fred Mintz, Lockheed Aircraft Co.

THE new Shock and Vibration Manual has been developed to the point where the methods of solving vibration isolation problems can be outlined. After further refinements and expansion, the manual will be issued by SAE Committee S-12 on Shock and Vibration.

The procedure now consists of three steps:

- Specification of the data required for the solution of a given problem.
- Calculating whether vibration isolators are needed.
- Determining the dynamic properties of the isolation system when the above step indicates isolation mounts are needed.

The manual will set up procedures to be followed by engineers who don't have extensive experience in the field. It will give procedures for problems having up to six degrees of freedom.

Data Needed for Solutions

To start a problem, data are needed on the equipment being mounted and the structure on which it is mounted. First, the equipment's weight, cg location, and fragility curve are required. The fragility curve is a single, continuous curve of sinusoidal amplitude versus frequency, defining the limits of motion below which failure or malfunction will not occur. This curve covers the entire frequency range of interest and is adjusted for factors of fatigue and superposition of several sinusoidal inputs.

Second, the free motion of the structure and its impedance must be known. With no equipment mounted on the structure, the free motion is a plot of frequency versus the sinusoidal displacement, velocity, or acceleration.

Is Isolation Protection Needed?

A new type of "transmissibility" is used as the yardstick to determine if an isolator is needed to protect equipment from the motion of the supporting structure. It is defined as:

$$H = \mu_f/\mu_s$$

where:

H = "Transmissibility"

μ_f = Allowable amplitude of equipment motion (fragility)

μ_s = Amplitude of free motion of structure

When the impedance of the source approaches infinity, the value and meaning of H approach the conventional transmissibility. H_m is the maximum value of H that the equipment can stand without damage.

A second H is also calculated. This is H_o and is defined as the ratio of the amplitude of motion of the equipment when mounted on the structure to the free motion of the structure. ($H_o = \mu_o/\mu_s$)

Both H_m and H_o are plotted against frequency. If H_o is greater than H_m at any point, isolation is required to protect the equipment.

Picking the Isolator

There is now no set of rules for directly picking the right isolator. However, the Committee is working on a repetitive procedure that will eliminate the need of educated guesses.

The way experts now pick the isolator is to compare the H_m versus frequency curve with the simple transmissibility curve of the isolator. By sliding the H_m curve up until it is just above the isolator curve at all points, a trial natural frequency of the system can be picked. Using this frequency, the system can be checked to see if the isolator will actually do the job.

To Order Paper No. 83A . . .
■ on which this article is based, see p. 6.

Simple procedures are being constructed to help the engineer solve vibration isolation mounting problems. A manual under preparation by SAE Committee S-12, Shock and Vibration, will tell when special mountings are necessary and how to determine their characteristics.

In page 62 of this issue, some of the vibration theory behind the manual is outlined. The manual itself will not contain this theory, but rather, it will be a series of steps that can be easily followed by an engineer not specially trained in vibration work.

A product of the Cooperative Engineering Program

CRC Speeds Activity in 1958, Research for Military Increases to 45%

A summary of CRC activities from the 1958 Annual Report of the Coordinating Research Council

A DEFINITE speeding up of developmental and test programs in the aircraft, automotive, and diesel fields is reflected in Coordinating Research Council activities during the past year. In addition, the number of research projects being handled has taken an upswing.

In contrast to research work executed for the Military Services, which in the past has amounted to approximately 40% annually, this year's percentage of CRC activity for the Military will rise to 45%. This pace is expected to continue for some time in view of unsettled world conditions and the rapid rate at which the Military is developing its equipment.

A 1957 study of the CRC organization by a group under the leadership of W. M. Holaday resulted in the revised technical committee structure shown in the accompanying chart. Here, CRC working groups and panels fall under the jurisdiction of three main technical committees. These committees are now considered the top CRC technical groups for all fuels and lubricants work.

The new organization facilitates the transmission of assignments to working groups in addition to speeding the approval of technical reports for industry use through elimination of one committee level from the former structure. Thus, *one* committee assumes the responsibility of:

- Indicating which projects are technically worth undertaking.
- Expediting those projects which require immediate handling.

The streamlined organization should make it easier to accept and carry out projects as well as to report to industry. As a result of the reorganization, it may be desirable to make some changes in group structure beneath the committee level.

The **CRC Industry Committee**, formerly the Assignment Committee, will review all proposed projects to make sure that industry management will support *worth-while* projects with necessary funds, manpower, and laboratory facilities. Although from a technical viewpoint, many problems warrant study, CRC will accept only those problems which industry management feels are of sufficient importance to justify expenditures of manpower and facilities.

CRC technical committee work will be reported each year to the American Petroleum Institute Automotive Research Committee to solicit support from the petroleum industry. It will also be reported to appropriate equipment industry groups to provide an opportunity for them to indicate interest and support.

Coordination Committee membership consists of seven; the chairman of the three main technical committees, the chairman of the Industry Committee, and three general members having intimate knowledge of CRC projects. The purpose of this committee is to insure consistent policy within the three technical committees. The committee may also assume technical supervision of some projects that, because of overlapping interest, do not logically fit into the activities of one of the three technical committees. Since CRC projects may have a high degree of military classification, it is desirable to place them under the jurisdiction of the Coordination Committee.

The CRC is currently working on 41 projects, dealing with 31 subjects. During the past year, six projects were initiated, two new, one an amplification, and two projects which are carried out on an annual basis.

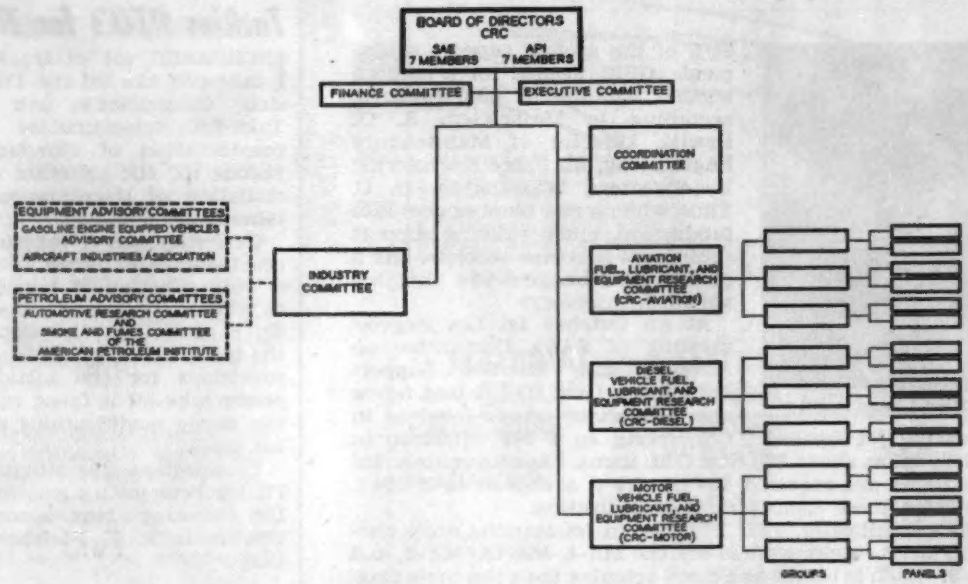
CRC technical reports, prepared as interim reports or as final reports upon completion of a project, are released by the appropriate CRC Committee to the Sustaining Members for publication or general distribution. Lists of all available CRC reports are published periodically in the *SAE Journal*.

Aviation Fuel, Lubricant, and Equipment Research

The **CRC-Aviation Committee** currently has under its jurisdiction ten projects, five dealing with fuels, and five with lubricants. Two of the fuel projects are being actively worked on by industry groups and constitute the bulk of the committee's work in the aviation fuel field.

The first of these deals with the subject of electrical discharges. The objective of the project is to determine the factors controlling the development of electrical discharges within aircraft fuel systems and the conditions under which such charges constitute a safety hazard.

The evidence indicates the igniting discharges can be generated within or by fuels flowing



Functional chart for Coordinating Research Council, Inc.

through piping or other equipment, and that fuel differences, as well as the equipment design, can influence the frequency of discharge.

Unfortunately, the state of the art lacks ability to predict the existence or degree of hazard which may exist under a given set of conditions. Lack of knowledge has become of real concern in the case of jet gas turbine powered aircraft, including commercial transports. This program is, therefore, proposed to determine:

1. What factors control the development of electrical discharges within aircraft fuel systems.

2. Under what conditions do such electrical discharges constitute a safety hazard.

Recognizing the complexity of the problem, the future program will include the following:

1. A study of the effect of tank size and shape and tank inlet geometry.

2. A comprehensive study of the properties of the fuel and how they are related to the problem.

3. Studies of the fundamental characteristics of the actual discharge.

The second important project is the work on the thermal stability of aviation turbine fuels. The scope: to develop practical and valid laboratory test techniques for predicting the high-temperature stability performance of petroleum hydrocarbon fuels in aircraft gas turbine engines.

During the past year, most of the work on this project has been focused on the testing of exchange samples in a real effort to secure better repeatability and reproducibility of the results from the CFR Fuel Coker.

The Fuel Thermal Stability Group is also working closely with the Wright Air Development Center in an advisory capacity on a series of flight tests to determine the significance of the laboratory technique in actual flight service. Thus far, the results are quite satisfactory, and an attempt is being made by the Air Force to expand this program. The Military are convinced of the need for some thermal stability limitation on aviation turbine fuels.

Another project under the jurisdiction of the commiittee is that on the handling of fuel within modern high-speed aircraft, which is concerned with the accumulation of data on air-gas solubility at very high flow rates. A research program on this subject is being carried out by the Atlantic Research Corp. under the guidance of a special CRC Advisory Group. This work covers the determination of the rates of solution and gas evolution from aircraft fuels in agitated tanks and fuel lines.

The other fuel project under the jurisdiction of the committee involves a study of the low-temperature flowability and pumpability of turbine fuels. The problem of combustion characteristics of turbine fuels has been dropped, pending further clarification of objectives.

There is a considerable amount of work being done on airframe lubricants. Projects include the development of techniques for:

- Predicting the high-temperature performance of lubricants for ball and roller bearings used in airframes.
- Measuring the effect of airframe and accessory lubricants to minimize fret corrosion in the equipment in which they are used.
- Evaluating the performance

Continued on page 117.

Ground Support Equipment

Major-General Hewitt

78% of the ground support equipment (GSE) needed for a modern bomber squadron is non-standard, according to Major-Gen. A. G. Hewitt, Director of Maintenance Engineering, Air Force Engineering Headquarters, Washington, D. C. Thus, when a new bomber goes into production, much existing support equipment becomes obsolete. As a result, GSE budgets are shooting skyward.

At an October 1st Los Angeles meeting of SAE's Committee on Aircraft and Missiles Support Equipment, Gen. Hewitt told fellow members about what's involved in up-dating jet fighters. Converting an F-84F squadron to F-100's takes about 220 new GSE items. Approximately 300 new items are required to convert a squadron to F-104's. *Too often* these items lack standardization.

More specifically, some 27 different jet starting units currently exist. Among them are the MA-1, MA-1A, MA-2, and MA-3. Each is bigger and more complex than the preceding. The system will continue to increase in size and unnecessary cost until better government/industry coordination occurs.

The MJ-3 hydraulic mule and a bomb navigation evaluator were also cited as complicated items of major expense. However, electronic test equipment still holds the lead as the largest GSE dollar expenditure.

Approximately 12,000 new supply items enter the Air Force inventory per month, according to Gen. Hewitt. Each must be analyzed for possible early obsolescence.

He also stated that a weapon system's design stage is *the* time to standardize. Consequently, there is hope that standard support and test equipment will be developed for the B-70, F-108, and many of the missiles now in research and development.

Lack of data has made it impossible for most contractors to attain maximum integration of common and standard equipment in weapon systems and support equipment. As a result, a technical information file on GSE is being developed jointly by the Air Materiel Command and industry. The target date for completion of this Air Force project is January 1959.

Recent Air Force policy is directed toward an examination of the following:

- The make/buy structure of contractors. This will be done to make use of as much existing GSE as possible, to increase standardization, and to reduce equipment costs.
- Multiple use equipment.
- Centralized procurement of appropriate prime equipment.
- Assigning to one depot the responsibility for technical coordination of all major test equipment items.

Gen. Hewitt concluded by pointing out that support equipment in many cases is more expensive and complex than the vehicle it supports. Too often support equipment has been considered a stepchild. ". . . I am hoping from the work of this Committee we will be able to further our program toward developing standardization in support equipment."

New Transmission Group Tackles PTO's for Trucks

INCREASED use of truck power take-offs has led the Transmission Committee's new Power Take-Off Subcommittee to the consideration of standard provisions for the selection and installation of transmission power take-offs.

Currently, power take-off manufacturers are forced to provide a wide selection of helical gears to mate with various transmission drive gears. At the same time, the truck owner whose truck lacks provisions for the installing of power take-off is faced with having costly modifications made to his truck.

To alleviate this situation, the PTO Subcommittee is looking into the following areas, according to Chairman R. E. Fletcher, Dana Corp.

- Speed/torque relationship.
- Various uses of power take-offs.
- Simplified installation procedures.
- Standard drive gear pitches and pitch line velocity.
- External envelop clearance for PTO and PTO drive lines.

Eleven engineers well versed in all phases of power take-off applications attended the first meeting of the PTO Subcommittee, which was held in Detroit last August.

Technishorts . . .

AIR SPRINGS — Seventeen engineers from 16 segments of the air suspension industry attended the first meeting of the Air Spring Subcommittee last September in Detroit. Chairman **J. T. Hoban**, Cadillac Motor Car Division, set things in motion by submitting a proposal on standard air spring terminology.

THERMOELECTRIC CIRCUITS AND PERFORMANCE CURVES for typical jet engine thermocouples are the subject of SAE's new Aeronautical Information Report 65. Methods of making various corrections for radiation, conduction, response rate, and gas velocity are also presented.

New High-Temp Alloys For Airframe Components

Based on paper by

J. C. EKVALL

Lockheed Aircraft Corp.

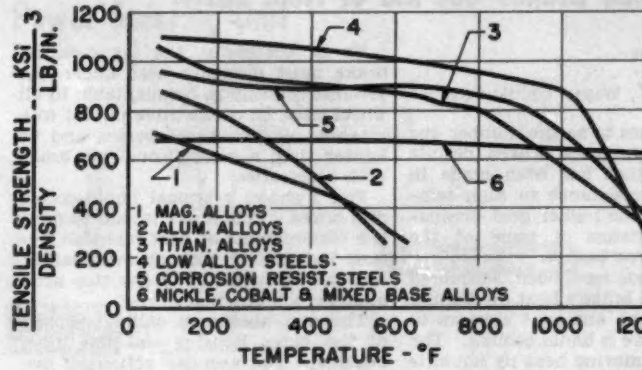
(Presented before SAE Southern California Section)

AIRFRAME components containing tension members can be built to operate at high temperatures and still weigh about the same as the present aluminum structures. Fig. 1 shows which of the available and the advanced development alloys can be used to attain this goal for various temperature ranges up to 1200 F.

Note:

- The marked superiority of the low-alloy steels, Thermold J and Peerless 56, for temperatures below 1000 F.
- The strength of groups 3, 4, and 5 alloys deteriorates rapidly above 1000 F.
- For temperatures above 1100 F, Udimet 500 emerges as the superior alloy.
- The maximum tensile strength—density ratio is higher for groups 3, 4, and 5 alloys at 650 F, 1000 F, and 800 F, respectively, than for the aluminum alloys at room temperature.

To Order Paper No. S109 . . . on which this article is based, see p. 6.



MATERIAL GROUP	MATERIAL DESIGNATION	TEMPERATURE RANGE °F
1. MAGNESIUM	ZE 11-H26 HK31A-T6	70 — 580 580 — 650
2. ALUMINUM	X2020 2024-T86 2024-T81	70 — 475 475 — 515 515 — 580
3. TITANIUM	Ti-4AL-3Mo-1V Ti-16V-2.5AL Ti-7AL-3Mo Ti-8AL-2Cb-1Ta	70 — 200 200 — 725 725 — 1000 1000 — 1200
4. LOW ALLOY STEEL	THERMOLD J PEERLESS 56	70 — 500 500 — 1200
5. CORROSION RESISTANT STEEL	419 422 (TH900) 419 A-286	70 — 330 330 — 870 870 — 1100 1100 — 1200
6. NICKEL, COBALT AND MIXED BASE ALLOYS	UDIMET 500	70 — 1200

Fig. 1—Comparison of maximum tensile strength-density ratios for various available and advanced development alloys.

Radiator Capacity Limits Hydrotarder

Based on paper by

ALBERT H. HETZEL, Hetzel Bros.

and

CLAUDE B. PETTY,

Parkersburg Rig & Reel Co.

PERFORMANCE ability of the hydrotarder is limited by the capacity of the radiator to dissipate maximum heat generated at various stages of horsepower being absorbed.

Fig. 1 shows the possible Btu generation per min by a hydrotarder at specified horsepower loadings.

The average 300 hp diesel engine radiator will reject about 15,000 Btu per min. Of course, atmospheric temperatures will affect the radiator's rejection capabilities.

A water surge tank is incorporated in the circulating system of the hydrotarder and acts as an energy absorption unit when the rejection capacity of the radiator is exceeded by the generated energy.

A temperature of 200 F in the circulating system will cause the hydrotarder to fade with resultant loss of counter-torque resistance and, therefore, speed-governing ability.

If the combined load, grade, and speed of the vehicle create energy exceeding the capacity of the radiator to dissipate same, provision should be made by the vehicle manufacturer to provide increased cooling capacity.

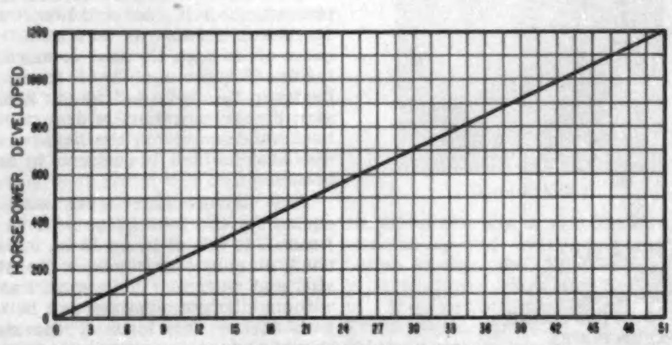


Fig. 1—Btu generation per min of hydrotarder at specific horsepower loadings.

To Order Paper No. 70D . . . on which this article is based, see p. 6.

Liquid-Cooled Brakes Get Rid of Heat Faster

Based on paper by

J. D. DUDLEY, Wagner Electric Corp.

HEAT continues to be the number one problem with truck brakes despite the progress that has been made in materials for resistance to high temperatures and the higher heat dissipation characteristics of some of the newer drum-type brakes.

Many methods have been considered to improve the brake's heat dissipating qualities but the one that appears to be most effective is liquid cooling. The principle of removing heat by liquid is not new but as far as brakes are concerned it has been thought of as impractical for production use because of the complexity and cost.

To be successful, the liquid-cooled brake must dissipate heat under the severest conditions, be adaptable to all wheel sizes, be competitive in cost to a retarder plus a service brake, and be lighter than a conventional air brake with accessories.

Fig. 1 shows a typical liquid-cooled disc brake. This brake is said to meet the requirements of heat rejection, retard indefinitely without overheating, and can be subjected to one stop after another without fade.

The cast aluminum caliper consists of the outer housing and the inner housing. The annular actuating piston is also aluminum and is sealed by O-ring piston seals. The lining disc is steel and has the lining bonded to both faces. The inner periphery is slotted to mate with the teeth on the driver. The ends of the teeth on the driver are tapered to help pilot the lining disc and driver together.

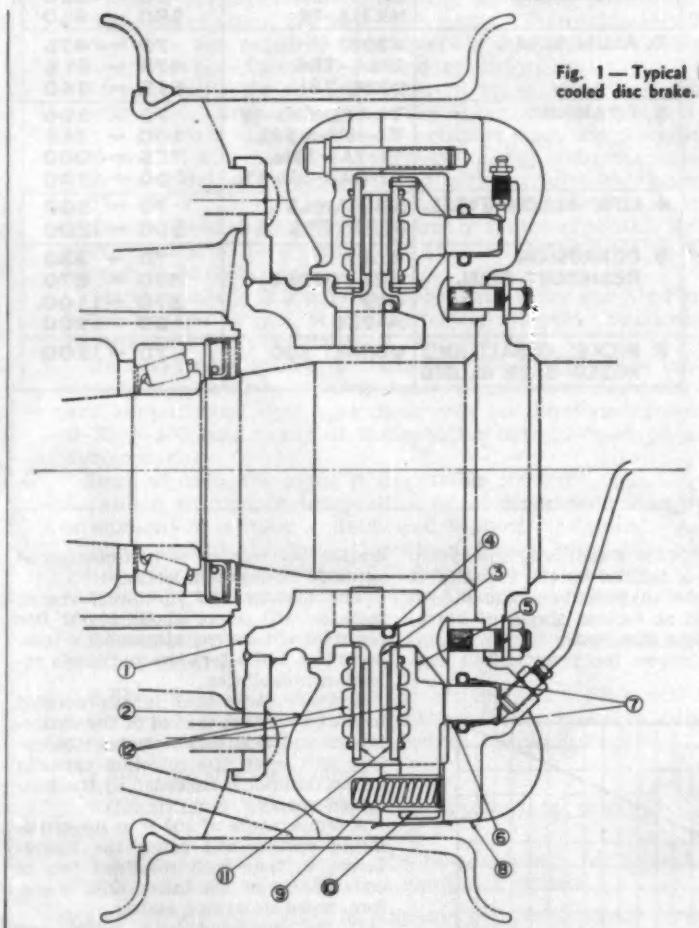


Fig. 1 — Typical liquid-cooled disc brake.

1 DRIVER
2 OUTER HOUSING
3 LINING DISC
4 LINING DISC ANTI-RATTLE RING
5 COPPER CARRIER
6 ACTUATING PISTON
7 ACTUATING PISTON SEALS
8 INNER HOUSING
9 BRAKE RETURN SPRING
10 AUTOMATIC ADJUSTING SLEEVE
11 COPPER FRICTION PLATES
12 COOLANT PASSAGES

The lining disc anti-rattle ring prevents rattling between the lining disc and the driver. The copper friction plates are riveted to the outer housing and the copper carrier and are sealed by means of O-rings.

The brake has an automatic adjuster to compensate for lining wear. This adjuster maintains a constant clearance between the copper wear surface and the lining by means of a brake return spring which is retained within the automatic adjusting sleeve that is pressed into the copper carrier. If the cup clearance is taken up before the lining and copper contact, the sleeve will slip in the carrier and thereby compensate for wear.

The liquid can enter on either side of the brake, depending on the axle mounting, and flow through the coolant passages to the back side of the copper friction plates.

The brake is protected from road splash and dirt and has no running seals. The brake is designed for air-over-hydraulic actuation using a power cluster with a ratio of 11 to 1.

The coolant used in the brake is the same as that used in the engine cooling system and is circulated through the brakes and back to the radiator by a belt-driven positive displacement pump. Using the coolant that is common to both the disc brakes and the engine cooling system (specific heat of ethylene glycol is 5.68 times that of iron, and water is 7.2 times that of iron) adds to the total heat sink that must be accounted for in a conventional-type drum brake to dissipate the same amount of heat.

A foot valve meters air to the disc brakes at a predetermined pressure for retarding the vehicle. When the pressure exceeds the preset pressure, the retarding valve opens and air is metered to the disc brakes and service brakes. The retarding valve can be put in operation or left out of the system by moving the selector valve located in the cab to retarding and service braking or service braking position.

The copper friction-surface material presents the best wear and heat-transfer characteristics at this time. Because of its high thermal conductivity factor (8.3 times that of iron), the heat can be dissipated to the coolant at a higher rate thereby preventing a heat build-up within the liquid-cooled disc brake which is common in drum brakes.

This liquid-cooled brake was designed for the present as well as the future. It will fit in an 18 in. wheel if truck manufacturers reduce the wheel size, and with very little modification, without diameter change, can be used with higher axle loads if the states should change their regulations.

Use of a disc brake is said to provide

continued on page 126

IHC's Tractors Feature New Power Steering Unit

Based on paper by

WILLIAM W. HENNING
International Harvester Co.

TWO models of the new IHC tractor line, the F-460 and the F-560, are equipped with a new power steering unit (Fig. 1).

The entire power unit is incorporated into the front bolster and uses an integral cylinder and rack mounted in an eccentric sleeve which provides rack and pinion backlash adjustment. The manual follow-up is through a ball-nut and screw, endwise motion of which operates the open-center-type steering valve. Smooth, shimmy-proof operation is said to be obtained without losing the desired degree of reversibility and operator feel.

Full control is retained in the event of hydraulic pressure failure and during towing of the machine with the engine dead. All hydraulic connections are O-ring sealed, with pipe thread connections completely eliminated. Bolster shaft bearings and rack and pinion are lubricated by hydraulic oil from the sump side of the steering unit.

To Order Paper No. 81B . . .
on which this article is based, see p. 6.

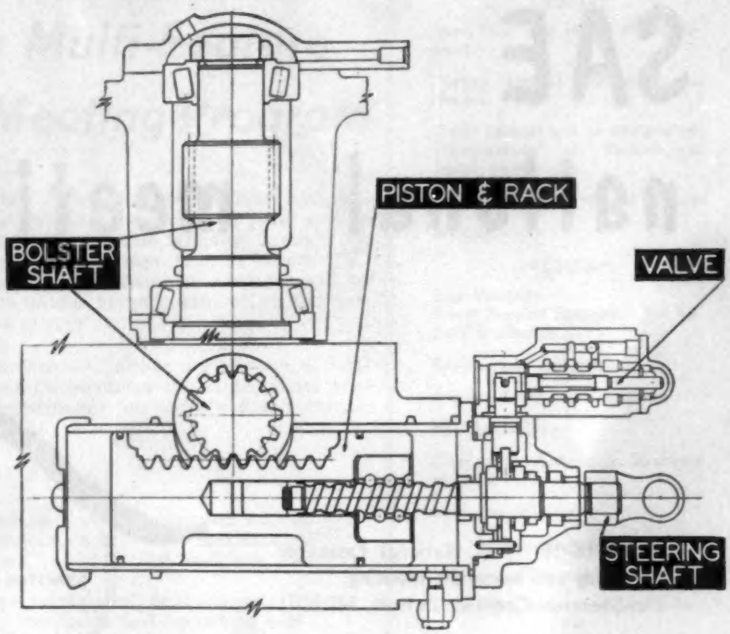


Fig. 1 — New power steering unit used on IHC F-460 and F-560 tractors.

O. K. Kelley Named Buckendale Lecturer

OLIVER K. KELLEY has been named to present the 1958 L. Ray Buckendale lecture and receive the fifth annual L. Ray Buckendale Award. Kelley, chief engineer of GMC's Buick Motor Division, will present his paper on "Design of Successful Planetary Gear Trains" on January 14, during the SAE Annual Meeting in Detroit.

Recognized as a distinguished authority in the technical areas of commercial and military ground vehicles, Kelley will direct his lecture toward filling the needs of young engineers and students for up-to-date practical knowledge.

The author will discuss the usefulness and application of planetary gear trains as well as the engineering techniques necessary for optimum design. A simple technique for calculating planetary gear ratios will be described which can be used to quickly determine the potential usefulness of any planetary configuration, as well as a discussion of some limiting factors of gear-set proportion. The author will also list some criteria which help to evaluate the potential of a planetary gear train schematic from a gear noise and structural viewpoint. Kelley will go into the sequence of approach to the detailed design of individual members including spacing of the pinions, mounting considerations, thrust directions, lubrication, and stress evaluation.

Kelley joined GMC's Cadillac Motor Car Division in 1927, and was trans-

Oliver K. Kelley

ferred to the Truck and Coach Division as special assignment engineer before joining GMC Engineering Staff in 1936. Three years later Kelley went to the newly established Detroit Transmission Division as assistant chief engineer where he remained until 1950 when he re-joined the Engineering Staff.

During his affiliation with GMC, Kelley has worked on the development of the original synchromesh and hydraulic transmissions, as well as helping organize and direct a new activity to further develop automatic transmissions for the entire field of passenger car, heavy-duty commercial vehicles, and U.S. Army military vehicles. His appointment as chief engineer, Buick Motor Division, was made in 1957.

An SAE member for 32 years, Kelley now serves as chairman of the 1958 Technical Board. He has also been wartime chairman of SAE Committee on Transmissions and Clutches and Drive Lines — Captured Enemy Equipment; chairman of the working subcommittee of the Hydrodynamic Drive Nomenclature Committee; and chairman of the Transmission Committee.

The Buckendale Lecture is presented annually in honor of the late L. Ray Buckendale, 1946 SAE president and vice-president in charge of engineering, Timken-Detroit Axle Co.

Ernest P. Lamb, chairman of the Buckendale Lecture Committee, will make the award presentation at the time of the lecture, Wednesday afternoon, January 14, 1959.

SAE national meetings

- January 12-16, 1959, Annual Meeting, and Engineering Display, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

- March 16-18, 1959, National Passenger Car, Body and Materials Meeting, The Sheraton-Cadillac, Detroit, Mich.

- March 19-20, 1959, National Production Meeting, The Sheraton-Cadillac, Detroit, Mich.

- March 31-April 3, 1959, National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Commodore, New York, N.Y.

- June 14-19, 1959, Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

- August 10-13, 1959, National West Coast Meeting, Hotel Georgia, Vancouver, B. C., Can.

- September 14-17, 1959, National Farm, Construction, and Industrial Machinery Meeting, Production Forum, and Display, Milwaukee Auditorium, Milwaukee, Wis.

- October 5-10, 1959, National Aeronautic Meeting, Aircraft Manufacturing Forum, and Aircraft Engineering Display, The Ambassador, Los Angeles, Calif.

- October 26-28, 1959, National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- October 27-28, 1959, National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- October 28-30, 1959, National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

V-Diesels Star on Multi-Feature '59 SAE Annual Meeting Program

SEVERAL thousand engineers will have the opportunity, at the 1959 SAE Annual Meeting, to get the first technical details of the new "V" and in-line diesel engines being introduced by General Motors. The Monday, January 12, presentation will include a description of these engines, first of several "V" diesels destined to appear in 1959. Several proved design innovations will be shown for the first time, together with the unique manner with which the new engines have been integrated with current models.

All of the 14 Activity and Advisory Committees, which are sponsoring sessions at this 1959 Annual Meeting, are rapidly finalizing the 31 technical programs that will bring into focus vital information on today's developments, techniques, and problems.

A few of the highlights are already known:

On Monday the program on testing aircraft components for nuclear fields will explore for the aircraft powerplant, missile and aeronautical engineers the aspects of radiation shielding, radiation test facilities, and radiation tolerant electronic equipment.

Later in the day materials for rockets and ramjets will be discussed with special emphasis on liquid propellants, dry lubricants and insulating coatings.

✦

Tuesday — How radioisotopes can be applied to the everyday tasks of the research labs, in quality control and in production, will be discussed at a morning session.

After lunch, materials and design engineers will be interested in learning more about glass as an automobile structural material.

A feature evening program on body imagineering will open the doors for a look into the future when the body features of our 1980 cars will be projected.

✦

Wednesday's program will include a symposium on braking of vehicles which is paramount to safety. Engineering analysis of aluminum brake drums and methods of cooling, gray iron brake drums, and lining materials will be undertaken.

As many SAE members are required to do considerable traveling as part of their jobs, they will be interested in learning about the work of the air transport industry in getting people from the city center to the airport and back.

✦

Thursday — All engineers are concerned with measuring things . . . performance, dimensions, strength, and so forth. The frontiers of measurement session will spotlight two facets of this field, physical measurements — a challenge to science and engineering, and subjective measurements in engineering.

At a luncheon program the production executive's job in the coming years will be anticipated.

The Firebird III Engineering and technical developments will be featured on the evening program with details of the gas turbine engine, the all aluminum engine that drives accessories, chassis features, and the many electronic components being shown and described.

✦

Friday completes the busy week with an exploration of the effects of higher speed and power on power train components, and later in the day there will be a program reviewing the catalytic converters, afterburners, and use of catalyst designed to reduce vehicle combustion products.

MONDAY

New "V's" and In-line Diesel Engines

Testing Aircraft Components for Nuclear Field

Diesel Exhaust and an Analysis and Interpretation of Turbocharged Diesel Performance

Materials for Rockets and Ramjets

Missiles

TUESDAY

Fuel Volatility

Power Support Equipment for Aircraft & Missiles

Radioisotope Applications

Aviation Fuels and Lubricants

The Aerial Jeep

Glass as an Automobile Structural Material

Body Imagineering

WEDNESDAY

Automatic Transmission Fluids

Let's Make a Better Brake Drum

Getting Airline Passengers to the Airport

Buckendale Lecture

Wear Testing and Problems in the Friction and Deformation of Solids.

Ground Handling Equipment for Airliners

Refrigeration of Trucks and Trailers

ANNUAL DINNER

THURSDAY

Power Steering — Present and Future

Accident Investigation

Frontiers of Measurements

Luncheon — The Production Executive's Job in the Future

Bringing Outdoor testing Indoors

Lightweight Highway Tractor Design

Firebird III

FRIDAY

Effects of Engine Speed and Power on Power Train

Construction aspect of AASHO Road Test Program

Tremendous Trifles in Manufacturing

Advantages of the Involute Spline

Vehicle Combustion Products — Report on Catalytics and Afterburners

Calling All SAE Consultants!

SAE Placement Service reports that the first issue of SAE Consultants has been received very favorably by both members who do consulting work and those seeking the services of these men.

Last year 1,500 copies of this list were distributed by the Placement Service. The backgrounds of 136 SAE members appeared in the 1958 issue.

A 1959 issue is being planned, and all SAE members interested in consulting are invited to register. (Last year's listings will be carried into the 1959 issue automatically.)

Registration forms may be obtained either from your Placement Service at SAE Headquarters, 485 Lexington Avenue, New York 17, N. Y. or from your local SAE Placement Chairman. The CLOSING DATE for the 1959 issue is DECEMBER 15, 1958.

SAE

BALTIMORE

November 13 . . . Frank E. Mamrol, chief design engineer, Piasecki Aircraft Corp. "Design Considerations of the VTOL/STOL Aircraft and the Aerial Jeep Program." Engineers Club, 6 W. Fayette St. Cocktails 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

BUFFALO

December 8 . . . SAE Past President Ralph Teetor, Perfect Circle Corp., Technical Speaker. William K. Creson, SAE President will be special guest. Special Feature: Past chairmen of Section to be honored.

CHICAGO

November 17 . . . George Brown, chief, computer center, Bendix Products Division. "Engineering Applications of Electronic Computers." Hotel La Salle, South Bend. Dinner 6:45 p.m. Meeting 8:00 p.m.

November 18 . . . Truck & Bus and Transportation & Maintenance Meeting. "Use of Plastics as Cab Material in Trucks." Knickerbocker Hotel, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Social Half-Hour 6:15 to 6:45 p.m.

December 9 . . . Passenger Car Meeting. "The New Studebaker Model X Passenger Car." Knickerbocker Hotel, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Model car to be displayed during Social Half-Hour from 6:15 to 6:45 p.m.

CLEVELAND

December 8 . . . Diesel Activity Meeting. Cleveland Engineering & Scientific Center, 3100 Chester Ave., Cleveland.

DETROIT

November 17 . . . Junior Activity. ESD Auditorium and Snack Grille, Rackham Educational Memorial.

December 8 . . . Production Activity Meeting. Banquet Hall & Large Auditorium, Rackham Educational Memorial.

INDIANA

November 13 . . . David T. Marks, development and design engineer, Cummins Engine Co. "A Forward Look on Engines." Continental Hotel, Indianapolis. Dinner 7.00 p.m. Meeting 8:00 p.m. Special Feature: Presentation of Certificates of Recognition for Long Time Members.

November 18 . . . Fort Wayne Division. Dinner and Plant Tour, Central Foundry Division, GMC, Defiance, Ohio. Time 6:30 p.m.

December 11 . . . T. F. Nagey, director of research, Allison Division, GMC. "Nuclear Rocket Propulsion — A Survey of Proposed Concepts." Continental Hotel, Indianapolis. Social Hour 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

METROPOLITAN

November 20 . . . Philip B. Hopkins, director, service development & training office, Chrysler Sales & Service Training Centers. "Let's Simplify Our Complicated Automotive Preventive Maintenance Procedures." Chrysler Training Center, 401 Theodore Friend Ave., Rye, N. Y. Tour starts at 4:30 p.m. Dinner 6:30 p.m. Meeting 8:00 p.m. Price $3.00 per person. For those who will not be driving their automobiles, buses leave 49th St., between Rockefeller Plaza & Sixth Ave. 3:00 p.m. Return 11:00 p.m.

December 4 . . . Air Transport Dinner-

SECTION MEETINGS

Meeting. Speakers will represent Boeing, Lockheed, Convair and Douglas. Also Pan American Airlines chief pilot, to give operational viewpoint. "New Jet Air Transports." Brass Rail Restaurant, Fifth Ave. between 43rd & 44th Sts. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

December 11 . . . Student Activity Meeting. Paul O'Shea, Mercedes Benz, Studebaker Corp. "Sports Cars." New York University, Sedgwick & University Aves., Bronx. Meeting 7:45 p.m.

MILWAUKEE

December 5 . . . Nelson E. Farley, director, Engine Laboratory, Chevrolet Engrg. Center, GMC. "Chevrolet's New Engineering Laboratory." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

November 17 . . . E. E. Chatterton, D. Napier & Son, Ltd., London, Eng. "The Deltic Diesel Engine." Mount Royal Hotel, Montreal. Dinner 7:00 p.m. Meeting 7:45 p.m.

December 6 . . . Ladies Night.

NEW ENGLAND

December 10 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles." M.I.T. Faculty Club, Cambridge. Dinner 6:45 p.m. Meeting 8:00 p.m.

NORTHERN CALIFORNIA

November 19 . . . Chuck Jackson, supervisor maintenance, Research Laboratory, Pacific Intermountain Express Co. "Laboratory Analysis—Maintenance Tool." Dinner 7:00 p.m. Meeting 8:00 p.m.

NORTHWEST

November 14 . . . V. C. Vanderbilt, chief research engineer, Perfect Circle Corp. "Valve Gears and Oil Consumption." Stewart Hotel, Seattle. Dinner 6:45 p.m. Meeting 8:00 p.m.

PHILADELPHIA

December 10 . . . Panel Discussion. G. E. Mintz, chief engineer, Bus Division, Mack Trucks, E. N. Hatch, director, Bureau of Franchises, Nassau County, A. D. Trumble, superintendent transportation, Niagara Frontier Transit System. "Developments in Immediate and Future Bus Transportation." Lehigh Valley Club, Allentown. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Feature: Afternoon tour of Mack Plant.

ST. LOUIS

November 11 . . . H. Holler, head, Navy Diesel Engrg., Nordberg Mfg. Co. "Development of a Lightweight High Output 4 Cycle Diesel Engine." Ambassador-Kingsway Hotel. Dinner 7:00 p.m. Meeting 8:00 p.m.

SOUTH TEXAS GROUP

November 12 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles."

SOUTHERN CALIFORNIA

December 8 . . . Fuels & Lubricants Dinner Meeting. "Octane Rating and Compression Ratio vs. Economy." Rodger Young Auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN NEW ENGLAND

December 11 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles."

SPOKANE-INTERMOUNTAIN

November 19 . . . Vern C. Vanderbilt, chief research engineer, Perfect Circle Corp. "Valve Gears & Oil Consumption." Caravan Inn, Spokane. Dinner 7:00 p.m. Meeting 8:00 p.m.

December 10 . . . Student Activity Night

SYRACUSE

December 9 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles."

TEXAS

December 5 . . . Fuels and Lubricants Meeting.

TEXAS GULF COAST

November 17 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles." Houston Engineering & Scientific Society Bldg., Houston.

WASHINGTON

November 18 . . . L. Hewin, chief, Aviation Division, Army Transportation Corps, Fort Eustis. "The Flying Jeep." Occidental Restaurant. Dinner 6:30 p.m. Meeting 8:00 p.m.

Rambling . . .

THROUGH THE

"Acquiring new businesses does not automatically guarantee success," according to Section Speaker Ralph F. Peo, Houdaille Industries' president and chairman of the board, "Many of us can recall instances where a company would have been wise to follow the proverbial shoemaker in sticking to its last instead of venturing into fields for which it has neither the necessary experience nor organization.

"If it is to contribute to healthy corporate growth, an acquisition program must be based upon clearly defined long range objectives. It also must be integrated into overall company policy and program." (**BUFFALO SECTION**, September 17.)

• • •

An ounce of preventative "medicine" is worth a pound of cure in trucks as well as people. The successful selection and maintenance of a truck, or fleet of trucks, demands the following primary considerations:

- Analysis of factors of hardship in service, temperature, road conditions, terrain, etc.,
- careful component selection in terms of ratio as well as load carrying capacity,
- detailed study of transmission selection in order that speeds can be fitted to terrain and engine miles reduced correspondingly,
- thorough examination of specifications submitted by manufacturers, drawn from their previous experience in units, equipment, operation, maintenance, etc.

High operation efficiency and low cost use in motor trucks is no accident, concluded Robert Cass, assistant to president, White Motor Co., at **TEXAS GULF COAST**, September 15.

• • •

What price octane number? It is conservatively estimated that the cost of raising each additional premium fuel octane number, for one year, is $40,000,000. (John Greytak, E. I. du Pont de Nemours & Co., **BALTIMORE SECTION** in September.)

One percent error in vehicle velocity, in a trip to the moon, might mean getting only half way there, or perhaps going beyond the moon and off into space. This and other problems of space flight were discussed by David L. Markusen at **TWIN CITY SECTION'S** Father and Son Meeting in September. Speaker Markusen, standing at left, with some of the younger members of his audience, is research section head, Aeronautical Division, Minneapolis-Honeywell Regulator Co.

An expert in the science of bio-astronautics, Brig.-General Don Flickinger, USAF, MC, spoke to **METROPOLITAN SECTION** in October on "Human Factors in Space Travel." Pre-meeting discussion included, A. T. Gregory, vice-chairman for Aeronautics, left; General Flickinger, director of Life Sciences, Air Research and Development Command, center; and S. G. Tilden, Jr., Section chairman, right.

CINCINNATI SECTION Chairman H. A. Truscott, seated, and three Governing Board members work out details of a new program dividing Section membership into small groups. Each group is assigned to one Governing Board member who makes direct telephone contact with each member on his list, informally discussing the program highlights for the next monthly meeting.

Board members pictured are, left to right, P. G. Belitsos; J. D. Stevenson; and J. F. Brown.

SECTIONS

W. E. Burnett
Chairman
Detroit Section

Reminiscences and Predictions

of the automotive world both were parts of **DETROIT SECTION'S** Annual Summer Meeting, September 12–14, at the Greenbriar, White Sulfur Springs, West Virginia.

Recollections of vehicle testing in the early days of the industry by O. E. Hunt, a director of GMC, included a comment that the driver's efficiency in test work rested largely on his ability to bring the car home. A winter test trip of 1000 miles often destroyed a set of four tires and two spares . . . economy tests were performed by pouring one gallon of gasoline in the tank and running it until the vehicle ran out of gas.

In one case, a four cylinder engine was being tested to study its sleeve valves, and during the test one cylinder seized and everything within that cylinder went to pieces. The test team than removed all the broken parts from the cylinder, cut off its connections and made their way back home on the remaining three cylinders.

Proving grounds of today are a result of a desire to provide an environment of safety for testers and the public; to furnish accuracy of testing performance with permanent conditions and desired road surfaces and grades; to standardize equipment procedures and instrumentation; and to compare a company's current and future products, as well as to compare its own with those of competitors.

Chairman and speakers of this session — entitled "Changing Times in Testing" — left to right, Chairman Ralph E. Cross, executive vice-president, Cross Co.; O. E. Hunt, director, General Motors Corp.; A. E. Bodeau, manager, technical service department, Engineering Research and Advanced Product Study Office, Ford Motor Co.; and L. M. Ball, assistant chief engineer — car dynamics, Engineering Division, Chrysler Corp.

It is possible that the American people could operate approximately **twice** as many lighter weight, more economical vehicles, for the same amount of money they are now spending to operate the present heavier and less efficient cars — reported James W. Watson of American Motors Corp. at **CLEVELAND SECTION**, September 8.

His conclusion was partially based on statements made by C. F. Kettering who, back in 1943, speculated that a sizeable, roomy, comfortable, good looking car could be produced at a total weight not exceeding 2000 lb and run 35–40 mpg of gas. Kettering's predictions were based on wartime requirements for increased production capacities in the aluminum and magnesium industries, and in high octane gasoline production. Watson's statement was based on today's **known possibilities.**

• • •

166 million motor vehicles have been produced in this country since 1900, and more than 2500 different makes of motor vehicles have been produced at one time or another. Employment figures for the manufacturing end of the auto industry shoot to about 8,000,000 people at normal times . . . or about one out of every seven employed persons in the U. S. depend on the industry for income. (Charles A. Chayne, vice-president in charge of engineering staff, GMC, **MID-MICHIGAN SECTION.**)

• • •

Panel members of **SPOKANE-INTERMOUNTAIN SECTION'S** Engine Clinic based their discussion on the audience's questions — as indicated on a 32-item questionnaire distributed to members before the meeting. Problems presented ranged all the way from "What causes pre-ignition in internal combustion engines?" to "What are the advantages of factory exchange clutches over rebuilding in the field?"

Panel members included Dale Huff, Clevite; Frank Cain, Allied Automotive; Glen Ruby, Perfect Circle; Dick Bailey, PurOlator; and J. C. Failor, Zollner.

Major considerations connected with the design of unmanned intercontinental or interplanetary vehicles were discussed in September at the **CHICAGO SECTION'S SOUTH BEND DIVISION.** At the speakers table, left to right, are C. Shaar, head-advanced development section, Bendix Products Division; Speaker R. Norling, senior systems engineer, advanced development section, Bendix Products Division; W. Kunz, manager of engineering, Bendix's aircraft engineering equipment; and W. E. White, vice-chairman of the South Bend Division.

About SAE Members

CARL L. HECKER has been elected president of The Oliver Corp. Vice-president of the corporation since 1948 and a director since 1950, he has been executive vice-president for the past two years. He joined the Oliver Corp. in 1946.

ALVA W. PHELPS will continue as chairman of the board, and chief executive officer.

ROY FRUEHAUF was elected chairman of the board and chief executive officer of Fruehauf Trailer Co. Prior to this, he was president of the company.

JAMES H. CARMICHAEL has been elected a corporate vice-president of Fairchild Engine and Airplane Corp. Carmichael will assume responsibility for overall management of the Fairchild Commercial Transport Division. He was formerly president of Capital Airlines, Inc.

F. E. NEWBOLD, JR., vice-president, who has been serving as general manager of the Engine Division of Fairchild Engine and Airplane Corp., will take over the newly created position of corporate vice-president to coordinate planning, product, and market development. He will also have overall responsibility for the operations of the three Long Island Divisions.

R. JAMES PFEIFFER, who served as executive director of corporate customer relations, has been appointed vice-president of marketing in the new Commercial Transport Division of Fairchild Engine and Airplane Corp.

THEODORE L. PREBLE has been elected vice-president of Ross & Co., Inc. He was previously supervisor of trucking, Tidewater Oil Co. Preble was 1941 SAE vice-president representing Transportation & Maintenance Activity. He also was an SAE Councilor in 1956-1957.


Hecker


Fruehauf


Carmichael


Newbold


Pfeiffer


Preble


Collyer


Needles

JOHN LYON COLLYER, chairman of the board of directors of B. F. Goodrich Co., has retired as chief executive officer of the company. He will continue to serve as chairman of the board.

IRA G. NEEDLES has been elected chairman of the board of B. F. Goodrich Canada, Ltd. He has, as of October 1, retired as president and chief executive officer of the company.

JOHN D. WRIGHT, president of Thompson Products, Inc., has been made chairman of the board and chief executive officer of Thompson Ramo Wooldridge, Inc., a company recently formed by the merger of Thompson Products, Inc., and Ramo-Wooldridge Corp.

FREDERICK C. CRAWFORD, chairman of the board of Thompson Products, Inc., will retire but will continue as director and head of the executive committee. He will also be retained as a consultant to the company.

FELIX W. BRAENDEL has been elected president of Groov-Pin Corp. Formerly, he was executive vice-president with the same corporation. Braendel has been with the corporation since 1936.

HARRY GRAHAM has become vice-president in charge of engineering for Clinton Engines Corp. His previous position with them was director of engineering. **JAMES H. DAVIDSON** has become vice-president of market sales and service for Clinton Engines Corp. His former position was manager of market sales and service.

WILSON T. GROVES has been made chief metallurgical engineer with Dana Corp. Groves will head the Engineering Metallurgical Department. Before joining Dana in 1948, Groves was affiliated with U. S. Steel Corp.


Wright


Crawford


Braendel


Graham


Davidson


Groves

PROF. MARION L. SMITH, of Ohio State University's department of mechanical engineering, has been appointed associate dean of the College of Engineering by the Ohio State Board of Trustees. He will be responsible for curriculum development, administration of scholarships and awards, and relations with alumni, industry, professional societies, and the public.

EUGENE B. DELANEY has been appointed general manager of the Wayne (Mich.) Division of Purolator Products, Inc. He is succeeded as branch manager of the Detroit sales office by **THEODORE E. COFFMAN**, a Purolator sales engineer.

CLARE L. HITCHCOCK has been elected vice-president for sales with Henney Motor Co. Previously, he was director of market research with Diamond T Motor Car Co.

RALPH L. JAESCHKE has been appointed chief engineer of the Dynamatic Division, Eaton Mfg. Co. He will also retain his present position as manager of research and development.

HARRY D. WELLER, JR. has been named vice-president of sales for the White Truck Division of White Motor Co. He will assume direction of the White domestic sales and service organization. Weller has been vice-president in charge of the company's eastern sales region, headquartered in New York.

THOMAS J. KIELY has been named manager of the Chicago regional sales office of the American Bosch Division of American Bosch Arma Corp., Springfield, Mass. Kiely has been with American Bosch since 1921 and has served in various engineering and sales capacities.

LOUIS H. WINKLER, metallurgical engineer with Bethlehem Steel Co., has retired. He joined Cambria Steel Co. in 1909, remaining with Cambria through its consolidation with Midvale Steel & Ordnance Co. and its later acquisition, in 1923, by Bethlehem Steel. In 1956, he was given the University of Missouri Honor Award for Distinguished Service in Engineering, and the American Petroleum Institute Citation for Service.

ARTHUR W. JUDGE is the author of "Gas Turbines For Aircraft" which has just been released by Chapman & Hall Ltd., London. The purpose of this book is to attempt to bridge the gap between the mostly descriptive and elementary type of textbook and the more academic kind by considering, briefly, the history and development of the light gas turbine and then the results of theoretical and experimental investigations, followed by accounts of typical gas turbines and their component systems.

EARL A. VENSTROM is now Metropolitan New York district manager for the Industrial Products Division, Warner Electric Brake & Clutch Co. Prior to this, he was a sales engineer with Koppers Co., Inc.

HUGO H. TRAEGER has been named assistant to the director of Dole Valve Co.'s automotive jobber replacement division. Formerly, he was a sales engineer with the same company.

DALE R. THOMPSON has become Southern California sales engineer with Hannifin Co. Thompson was application engineer with Western Gear Corp.

ROBERT N. JANEWAY has moved the offices of Janeway Engrg. Co. to 1360 Mt. Elliott, Detroit. Janeway was formerly director of dynamics research with Chrysler Corp.

FRED S. MACKEY, A. O. Smith Co. vice-president, is president of the Milwaukee Athletic Club this year.

GLENN S. BEIDLER has become structures engineer with Chrysler Missile Division, Chrysler Corp. Prior to this, he was a design engineer with Convair Division of General Dynamics Corp.

A. B. MARSHALL, Detroit district manager of Carter Carburetor Division of ACF Industries, Inc., has retired after nearly 28 years of continuous service to the company.

GERALD D. GRIFFIN has become eastern district sales manager of the Axle Division, Eaton Mfg. Co. Previously, he was assistant to the sales manager of the Axle Division.

CHRIS NYBERG retired on Sept. 30, 1958, after 48 years in the agricultural implement engineering field. He has been with Ford Tractor and Implement Division, Ford Motor Co., for the past four and one half years. Prior to that he was with the Oliver Corp. for 20 years, and also had worked with the Advance Rumely Co., and Allis-Chalmers Mfg. Co. He will maintain his home at 4 Pioneer Ave., Battle Creek, Mich.

CHARLES K. TAYLOR will represent the Acme Chain Corp. of Holyoke, Mass., in Michigan, with headquarters at the Fisher Bldg. in Detroit. Taylor is also president of Lor-Mac Associates.

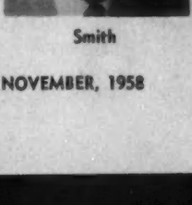
LT.-COL. SIDNEY G. HARRIS, USAF, has just completed the special six week course in Petroleum Pipeline Technology at the University of Texas Extension, Lee College, Baytown, Texas. He is petroleum staff officer and chief, Petroleum Branch, Materiel Directorate, Headquarters, Eight Air Force, Strategic Air Command, Westover AFB, Mass. Colonel Harris has been a member of SAE for 35 years.

GEORGE O. GALE was named manager of engineering for the DeSoto Division, Chrysler Corp. He will be responsible for coordinating styling, engineering, manufacturing, and quality activities. He formerly was assistant chief engineer for DeSoto Division.

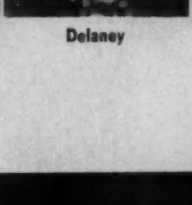
I. JAMES ELMORE is now assistant project engineer at Roy S. Sanford Co., Oxford, Conn. His responsibilities will center on liquid-cooled brake development and related projects.

PAUL S. SILBER is now design engineer of Aerojet-General Corp. Formerly, he was a design engineer with Lincoln Division, Ford Motor Co.

EDWARD H. HEINEMANN has been appointed director of combat aircraft systems engineering for Douglas Aircraft Co., Inc. In his new position he will report to **ARTHUR E. RAYMOND**, Douglas' vice-president — engineering, and a former SAE Councilor. Heinemann's duties will encompass complete weapon systems, including missiles, as they relate to aircraft. He has been chief engineer of Douglas' El Segundo division since 1936.



Smith

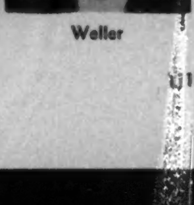


Delaney

Coffman

Hitchcock

Jaeschke



Weller

SAE Father And Son

JOHN F. CREAMER, SR., president of Wheels, Inc., as he completes 40 years as a wheel specialist, explains the automotive wheel design in popular use by Ford 40 years ago to **JOHN F. CREAMER, JR.**, a vice-president of the company. John Creamer, Sr. has been a member of SAE since 1920 and his son has been a member since 1956.

S. E. BERGSTROM, executive vice-president of Cincinnati Milling Machine Co., gave the opening address at the American Institute of Electrical Engineers' Tenth Annual Machine Tool Conference, Oct. 13–15.

RONALD E. TRENKNER was formerly with General Electric Co. as manufacturing engineer. He is now a mechanical engineer with Sperry Gyroscope Co.

C. RAYMOND ZINK, JR. has been named to direct general sales of automotive original equipment for Electric Auto-Lite Co.'s electrical products group. Formerly, he was chief of sales engineering for the company.

ARTHUR STURWOLD, Four Wheel Drive Auto Co., was awarded an engraved silver bowl which is presented annually to the FWD district sales manager who does the best overall selling job.

PAUL ALLMENDINGER, formerly assistant chief engineer, has been made chief engineer of the Instrument Division of Stuart-Warner Corp. Allmendinger is chairman of the SAE Student Committee.

HARDY G. REYNOLDS has retired as general sales manager of United Engine & Machine Co., Inc. Reynolds will continue to be available on a consultation and advisory status.

WILLIAM W. VANDERCOOK has been named director of maintenance and purchases with F. J. Boutell Driveaway Co., Inc. Formerly, he was superintendent of maintenance with the same company.

FREDERICK J. PORT is now general manager of the Automotive Division of Electric Storage Battery Co. He was formerly manager of manufacturing and engineering of the Automotive Division.

W. WAI CHAO has been staff engineer with Curtiss-Wright Corp. Chao is now chief propulsion engineer with Space and Missiles Division, Bell Aircraft Corp.

THOMAS R. EVANS has been named sales manager for Fine Metals and Chemicals Division, Electro Metallurgical Co. Evans had been metallurgical engineer in charge of sales with this company.

KENNETH T. WALDEN was made head of the Retaining Ring Division, Ramsey Corp. His work will include coordination of sales, advertising, sales promotion, and market planning. Before joining Ramsey, he was with York Corp. in engineering and sales.

HARRY H. WHITTINGHAM, executive vice-president of Long Mfg. Division of Borg-Warner Corp., has taken on the added duties of assistant general manager of the division.

EDGAR H. DIX, JR., assistant director of research for the Aluminum Co. of America, has retired. Dix had been with Alcoa since 1923, when he joined the Alcoa Research Laboratories at New Kensington as chief of the metallurgy section. Among the many awards and medals Dix has received for his work in aluminum research are the Francis J. Clamer medal, which was awarded to him by the Franklin Institute in 1947, and the Albert Sauveur Achievement award given to him by the American Society for Metals in 1956.

LOUIS M. BLANCHETTE, formerly a resident engineer for the Indianapolis power steering plant, Chrysler Corp., has been appointed to the staff of **HERBERT M. BEVANS**, executive engineer, Central Engineering Division, Chrysler Corp. Blanchette has served Indiana Section as membership chairman in 1957 and is 1958 vice-chairman — passenger car.

J. T. MOREN, who was formerly supervisor of the heating and air conditioning laboratories of Chrysler Corp., succeeds Blanchette as resident engineer, Indianapolis power steering plant, of Chrysler.

ALEX L. HAYNES has been elected chairman of the Vehicle Safety Committee of the Automobile Manufacturers Association. He had been director of engineering research and advanced product study for Ford Motor Co. Haynes, who will serve in the post for a two-year term, succeeds Howard Gandelot, staff engineer, General Motors Corp.

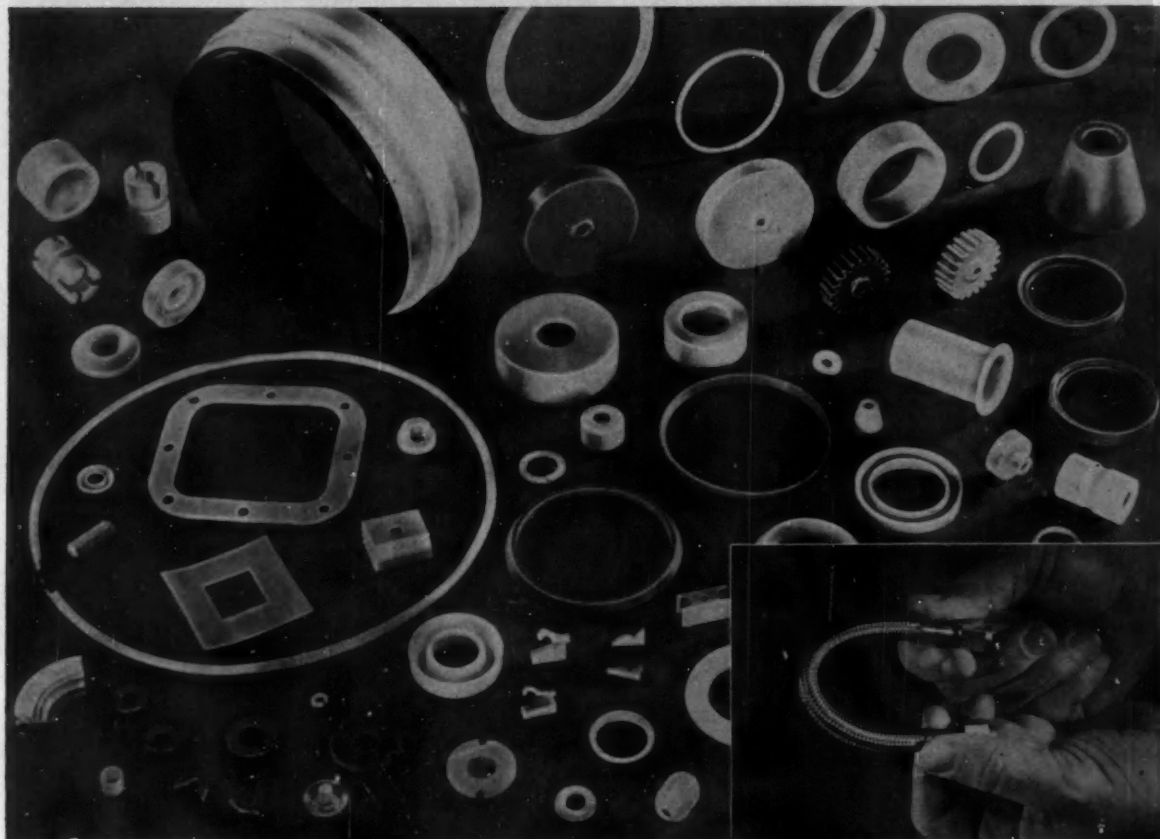
CLYDE WILLIAMS of Clyde Williams and Co., Columbus, Ohio, has just completed a six week business trip in Europe. Dr. Williams, former president of Battelle Memorial Institute, visited Brussels, Zurich, Munich, Vienna, Florence, Rome, Madrid, Paris, and London.

RAYMOND O. OYLER has become director of sales of Bunting Brass and Bronze Co. Formerly, he was general sales manager of the New Departure Division, General Motors Corp.

FELTON H. HAVINS has been named director of sales engineering for Anadite, Inc., of Texas. Havins was formerly chief project engineer with Brunswick-Balke-Callendar.

Walden — Whittingham — Oyler — Havins

Bring R/M's greater experience, better facilities, to bear upon all your TEFLON* problems

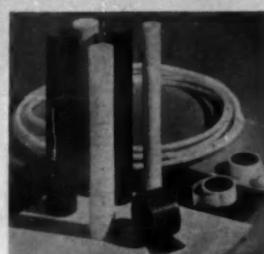


There is no substitute for the years of experience which Raybestos-Manhattan engineers have had in handling "Teflon"—nor for the unequaled plant facilities which implement this know-how. That is why we suggest that you come to R/M for *all* your "Teflon" needs.

The extruding, molding, machining, and bonding of "Teflon" is an old story at R/M. We are familiar with applications in the automotive and aircraft industries, where "Teflon" serves better than any other material, and we will be glad to fabricate parts and components to your precise specifications.

In addition, we can supply you with the other R/M "Teflon" products, such as flexible "Teflon" wire braid covered hose, "Teflon" sheets, tape, tubes, rods, and bondable "Teflon." Get in touch with your nearest R/M district office for the "Teflon" products you require and engineering information. Or write us for further information and literature.

*A Du Pont trademark



Other R/M "Teflon" products useful to your industry include centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; parts painstakingly machined to your specifications. Our mechanical grade of "Teflon"—Raylon—has many characteristics of virgin "Teflon."

R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1 • LOS ANGELES 58 • MINNEAPOLIS 16 NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3 • PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

OBITUARIES

V. A. CROSBY . . . (M'44) . . . manager of Automotive Development of Climax Molybdenum Co. . . . 1952 SAE vice-president representing Engineering Materials Activity . . . died October 2 . . . born 1893.

PAUL E. KRAMME . . . (A'41) . . . president of P. E. Kramme, Inc. . . . died September 2 . . . born 1897.

S. CLIFFORD MERRILL . . . (M'36) . . . assistant general manager of the Automotive Division, Timken Roller Bearing Co. . . . died September 20 . . . born 1897.

WILLARD L. HUPPERT . . . (M'53) . . . technical service manager with Motor Coach Division, General Motors Corp. . . . died March 12 . . . born 1896.

CLARENCE A. DYER . . . (A'44) . . . fleet superintendent for Lee & Eastes, Inc. . . . died May 21 . . . born 1889.

AUBREY A. BURROWS . . . (A'33) . . . vice-president of Hugh C. MacLean Publications, Ltd., and president of Acton Burrows, Ltd., publishers of "Canadian Transportation" . . . died July 25 . . . born 1888.

C. DON HICKS . . . (A'57) . . . vice-president, staff member of Consolidated Foundries . . . died June 24 . . . born 1916.

CARL P. NOTTINGHAM . . . (M'47) . . . designer, New Holland Machine Division, Sperry Rand Corp. . . . died June 16 . . . born 1907.

HAROLD P. HENNING . . . (M'53) . . . operations manager of the air transport section, General Motors Corp. . . . previously he was an executive pilot for GM . . . died September 12 . . . born 1901.

ARTHUR R. DUPUIS . . . (M'53) . . . superviser of vehicles for Bell Telephone Co. of Canada . . . died September 21 . . . born 1915.

A. F. NOTLEY . . . (M'47) . . . aviation safety advisor for the Civil Aeronautics Administration, International Airport of San Francisco . . . died August 26 . . . born 1894.

OSCAR A. ESKUCHE . . . (M'16) . . . engineering consultant with Stulen Engineering Co. . . . died August 20 . . . born 1881.

JOHN PARKER SMITH . . . (M'32) . . . patent attorney, with offices in the First National Bank Bldg. of Chicago . . . died September 2 . . . born 1890.

EDWARD F. ROBERTS . . . (M'16) . . . retired as general superintendent of Packard Motor Co. . . . died September 24 . . . born 1875.

JAMES R. GLAZEBROOK . . . (M'30) . . . was manager of industrial friction materials division, Johns-Manville Corp. . . . resigned recently from Johns-Manville to take an active part in operation of the Louisville Grocery Co., a wholesale concern in Kentucky . . . died August 23 . . . born 1907.

FREDERICK M. PAULL . . . (M'41) . . . general service and parts manager of Bishop, McCormick & Bishop . . . died August 20 . . . born 1887.

New extreme-high-temperature lubricants for missiles and supersonic aircraft SHELL ETR GREASES

One of the serious lubricating problems faced by designers of missiles and supersonic aircraft has been solved by scientists at Shell Research Laboratories.

The problem: to find a grease which would permit components to operate with certainty under extreme high temperatures. Co-operation with representatives of bearing manufacturers and military personnel resulted in a completely new class of greases—SHELL ETR GREASES.

These greases can easily withstand temperatures up to 600°F. They give superior lubricating performance because of a special thickener—an organic vat dye—which has exceptional heat stability and jelling efficiency.

If you are presently in the market for an ultra-high-temperature-range grease, we will be glad to provide more information on Shell ETR Greases.

SHELL OIL COMPANY

50 West 50th Street, New York 20, N.Y.
100 Bush Street, San Francisco 6, Calif.

SHELL

CRC
Speeds Activity

continued from page 99

of greases under slow, high-temperature, highly loaded, sliding motion.

- Use in field studies of bonded solid lubricant coatings.

Diesel Vehicle Fuel, Lubricant, and Equipment Research

One important project of the **CRC-Diesel Committee** is railroad lubrication. The Railroad Engines and their Lubrication Group has prepared a program which involves:

1. A Survey Panel to conduct a survey of the railroads by personal visits in an effort to outline the problem areas in so far as the severity of each problem area is concerned.

2. An attempt to study the existing problem areas on which work should be conducted.

Five problem areas in which lubricating oil may have an effect include engine deposits, engine wear, corrosion, friction, and useful life. It is recognized that some tests are available for some of these areas, while for others, none exist.

3. Determination of the applicability of current tests to these problem areas.

4. Determination of areas for future work.

The CRC-Diesel Committee has been acting in an advisory capacity with the U. S. Navy on problems associated with the main propulsion engines in submarines.

A compilation of general techniques for full-scale diesel-engine testing is being prepared under the guidance of the CRC-Diesel Committee.

The past few years have revealed the need for improvements in the method for measuring smoke in the exhaust of diesel engines. Improvements in the photoelectric type of smokemeter are being studied, along with an evaluation of the continuous-recording filtering smokemeter. Rather than having one type of meter which is best under all conditions, it is felt that each of these

continued

CRC

Speeds Activity

continued

types of meters may have advantages under certain conditions.

Motor Vehicle Fuel, Lubricant, and Equipment Research

The **CRC-Motor Committee** now has under its jurisdiction some 21 projects, the most important of which having to do with exhaust gas composition. This CRC project involves several approaches which include:

- Monitoring, in an advisory capacity, research being conducted at the Bureau of Mines on gas chromatography.
- A sampling and analysis program to develop better techniques.
- A variables program to study the effect of engine, fuel, and operating variables on exhaust gas composition.

The vapor-lock work of the CRC-Motor Committee includes the development of a technique to:

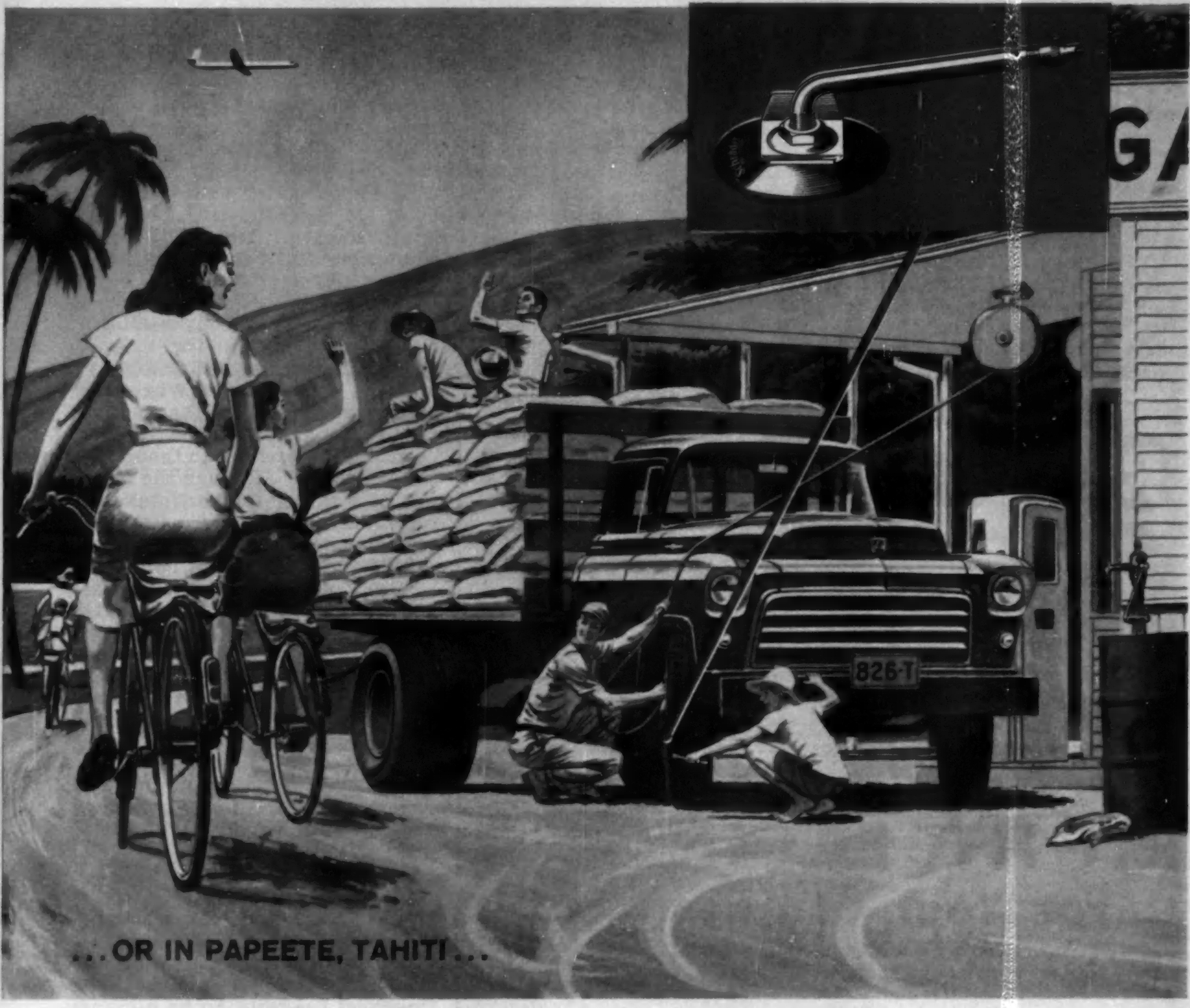
- Survey the vapor-handling characteristics of current automobiles.
- Develop a better expression for measuring vapor-lock than Reid vapor pressure at 100 F.

A carefully detailed program has been drawn up to conduct work which was run at the Ford Proving Ground in Kingman, Ariz., during the summer of 1958. Participants included General Motors Corp., Ford Motor Co., and American Motors Corp. In the 1958 octane-number requirement survey, a total of 550 cars will be tested, 400 of which will be used in a statistical survey of 1958 model cars and 150 of which will be selected models of special interest. Determination of octane requirement data over the operating speed range will be made, as well as the maximum octane-number requirement of the vehicle, and observations of surface-ignition phenomena, such as wild ping and rumble.

The CRC-Motor Committee is

continued


ATION
KING COTTON
WHETHER IN MEMPHIS, TENNESSEE...



CAN AIR-SERVICE TODAY'S TIRES

years of tire valve standardization make it easy

On the other side of the world, servicemen are using the same American tools, parts and methods to service vehicles as the man in the station down the block. Tire service is fast and easy because of standardization, but this situation didn't just happen. The U. S. Automotive, Tire and Tire Valve Industries combined their skills and experience not only to maintain highest quality while mass producing at lowest cost, but to produce interchangeable air valves and tools that make service possible anywhere a vehicle goes. Schrader's job is to utilize all the Industry know-how and produce the safest, most practical and dependable valves for all types of pneumatic tires.

Count on quality Schrader Tire Valves to match the performance of your vehicles . . . because the "Ace of Standardization" design can be serviced anywhere in the world.

Schrader®
a division of SCOVILL

A. SCHRADER'S SON • BROOKLYN 38, N. Y.
Division of Scovill Manufacturing Co., Inc.

FIRST NAME IN TIRE VALVES

FOR ORIGINAL EQUIPMENT AND REPLACEMENT

CRC

Speeds Activity

continued

actively investigating methods of evaluating the antiknock quality of very-high-octane-level fuels. The interrelationship of the ratings from various laboratory knock test techniques and knock performance of full-scale vehicles is also being studied.

As part of this problem, the significance of surface ignition, combustion-chamber deposits, and the user relationship to various erratic combustion phenomena are being studied. To evaluate the knock ratings of premium quality fuels in 1958 model cars, a road knock rating program has been planned. Primarily, the effects of throttle positions on fuel ratings and rumble tendencies of these fuels and engines will be investigated. Any work on laboratory knock ratings is being closely coordinated with the work of ASTM Research Division 1 on improvement of repeatability and reproducibility of the current laboratory test methods.

The project on the measurement of instantaneous combustion temperatures at the Massachusetts Institute of Technology and the University of Wisconsin will be concluded at the end of the year, and suitable reports prepared for issuance to the sponsoring groups. Although the work was of a rather fundamental nature, much useful information on temperatures inside the combustion chamber has been obtained.

A new project which has just begun to receive considerable attention is on seal performance. The objective of this project is to develop research techniques that are significant in terms of predicting functional seal performance in actual operation with primary emphasis on the problems related to; gasoline and fuel systems, including fuel dispensing systems; with engine lubricants; power transmission fluids; and gear oils.

In developing a CLR Oil Test Engine, a technique was sought for evaluating the high-temperature oxidation characteristics of lubricating oils to replace the Chevrolet L-4 test. In its present state, the new test technique (designated CRC Research Technique L-38) is as good as the L-4 test and has promise of being a better test. The Ordnance Corps has asked the petroleum suppliers submitting oils for qualification to include L-38 test results where possible, so that a background of experience can be developed. It is expected that if the current series of L-38 tests confirm the expectations of the Group, the Ordnance Corps will make the L-38 an alternate to the L-4 for qualification of military oils.

A second use of the CLR Oil Test Engine is being studied — that of evaluating the moderate-duty varnish and sludge-formation characteristics of lubricating oils. The Ordnance Corps is conducting an 18-month field test on approximately 20 new V-8 and 6-

continued

CRC

Speeds Activity

continued

cyl passenger cars under moderate or light-duty service for the CRC Group. This information will also be correlated with the CLR Oil Test Engine results.

A diesel cylinder head version of the CLR Oil Test Engine has been designed and manufactured. One of these cylinder heads is now in operation, and a CRC Advisory Group is reviewing its design and operation.

A considerable part of the work of the CRC-Motor Committee, particularly in the lubrication field, is concerned with Ordnance problems, such as the development of adequate techniques and reference lubricants for evaluating gear lubricants operating under conditions of increasing severity imposed by the high powers, weights, and speeds of both commercial and military vehicles.

A report has been issued covering an improved research technique for the determination of load-carrying wear, and extreme-pressure characteristics of gear lubricants in axles, under conditions of high-speed low-torque operation, followed by low-speed high-torque operation, which has given results comparable to those obtained in field tests run by the Ordnance Corps at Yuma, Ariz.

A new technique for evaluating the scoring tendencies of gear oils has been developed. The use of a system of reference gear lubricants has permitted the equipment manufacturers to measure the requirements of their axles, and these data, together with actual torque measurements in the gear sets, have provided technical information which made it possible to develop improved techniques.

Coordinated Projects

Fuel storage stability studies cover not only the study of motor gasolines, but also jet and diesel fuels, and as such, does not fall within the specific scope of the individual technical committees. Therefore, this work has been set up under the guidance of the CRC Coordination Committee.

continued from page 102

the following advantages over the drum brake:

1. Reduced mechanical deflections due to the construction of the disc and the housing.
2. Thermal expansion perpendicular to the plane of the applied force; thus displacement is not affected.
3. Uniform loading on the lining surface.
4. Lining area can be increased by adding additional friction surfaces.
5. Less unsprung weight than conventional air brakes with accessories by as much as 124 lb per axle.

To Order Paper No. 96C . . . on which this article is based, see p. 6.

Cars Still Have Fuel Octane Problems

Based on talk by

JOHN GREYTAK

E. I. du Pont de Nemours & Co.

(Reported by Dale E. Woomert, SAE Baltimore Section Field Editor)

IN NORMAL combustion the flame front moves at about 60 mph. In spark knock, pressure waves up to 6000 mph originate in the end gas. It is these shock waves that cause the noise, and may cause damage. Knock is essentially controlled by or a function of three fundamentals: pressure, temperature, and time.

The basic scale for octane requirements is the primary reference fuels, which are blends of isooctane (100 octane number) and normal heptane (0 octane number). The octane number of other fuels is determined by comparison to blends of these fuels. This may be done in the laboratory in a CFR engine. Two methods are used —motor and research; the principal differences being in speed and temperature. The motor method is the more severe.

What price octane number? It is conservatively estimated that in this country, the cost to raise premium fuel one octane number is $40,000,000 per year. What price road ratings? These are also expensive and laboratory tests are used in conjunction with correlation equations to screen fuels.

Part-throttle knock is rapidly becoming a big problem in the modern car. For example, in a particular 1958 car, the research requirement is 99 octane number at wide-open throttle. This drops to 96 octane number at 6 in. Hg vacuum and then rises to a peak of 101 octane number at 14 in. Hg vacuum. Part-throttle knock usually occurs as low speeds and the motor number more closely matches operating conditions.

To the published CRC definitions of

abnormal combustion should be added hot starting noise and thud. Hot starting noise may be eliminated by cranking the engine faster, which means a larger starting motor. Thud is similar to rumble in sound but is controlled by spark advance instead of deposits.

Random Vibration Testing Simplified

Based on paper by

ALLEN J. CURTIS, Hughes Aircraft Co.

FATIGUE damage in actual environments can be found in accelerated lab tests by using an "equivalent peaks" technique. The effect of low-intensity long-time random vibrations can be found by testing a part at a short-time high-intensity vibration level. This is done by calculating the number of times a damaging peak acceleration is applied to a part. The same number of peaks are then applied in an accelerated lab test. Since the vibrations being considered are of the random type, probability density functions for the distribution of the magnitude of the peaks are used.

Narrow-band random vibration is assumed since most fatigue damage occurs at resonant frequencies. The Rayleigh distribution is used to represent this condition. The ratio of actual time (low-intensity) to test time (high-intensity) is:

$$T_1/T_2 = \exp\left[\frac{a_{pe}^2}{2\sigma_1^2}\left(1-\frac{\sigma_1^2}{\sigma_2^2}\right)\right] = \exp\left[\frac{a_{pe}^2}{2\sigma_1^2}\left(1-\frac{W_1(f_o)}{W_2(f_o)}\right)\right]$$

where:

a_{pe} = Maximum peak acceleration that will not produce damage if applied for a long time

σ^2 = Mean square acceleration in the band

$W(f_o)$ = Average acceleration spectral density in the band, assumed known for environment and test conditions

The time ratio tells the test engineer how long he should run his high-intensity test, $W_1(f_o)$, to reproduce the damage that would result from low-intensity, $W_2(f_o)$, random vibration occurring in the actual part environment. The test is run at the same center frequency, f_o, as the actual environment.

The ratio a_{pe}/σ_1^2 can be approximated by using a single-degree-of-freedom model or knowing the maximum single-frequency vibration that will not cause damage.

In general, the time ratio will vary with frequency and each frequency of interest should be investigated separately. If a broad-band excitation is used for testing, some average of the equivalent times has to be used.

To Order Paper No. 83C . . . on which this article is based, see p. 6.

New Members Qualified

These applicants qualified for admission to the Society between September 10, 1958 and October 10, 1958. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Dennistoun Johnstone (A).

Atlanta Section

L. J. Galati (M), James P. Trebes (M).

Baltimore Section

John Koneck (J).

Buffalo Section

Allen Jerome Baker (J), Marvin H. Bryant (M).

Canadian Section

James R. Knox (A), Beverley Charles Price (M), Leland E. Spencer (M).

Central Illinois Section

Capt. Donald Lee Harvey (J), Edward R. Joseph (A).

Chicago Section

Bellman D. Jones (A), H. W. Matthews (A), John L. Mickle, Jr. (M), E. E. Prather (M), Richard Allen Sault (J), Robert P. Smith, Jr. (M), William J. Sonnemaker (M), David Spear (M).

Cincinnati Section

Lucius A. Sullivan (A), Richard B. Williams (J).

Cleveland Section

Robert C. Allbery (A), Earl C. Davis (A), Russell H. Edwards (A), William S. Giles (J), Peter Albert Hassell (M), William N. Murton (A), David Edward Rees (A), Samuel Elliot Rogers (J).

Colorado Group

Thomas Macaluso (A), Ronald James Steen (J).

Dayton Section

Austin D. Bishop (M), George G. Chambers (J), John Franklyn Hedge (M), Charles C. McLean (J), Fred Walther (J).

Detroit Section

Raymond G. Antos (J), Eugene S. Barc (J), Richard Alan Beyer (J), Harry N. Copp (J), Wendell R. Dance (J), David A. DeLong (A), Arthur E. Ellis (J), Ernest E. Fehlman (M), Paul A. Gates (J), Ernest B. Harper, Jr. (M), Donald Ray Herda (J), Wilbur T. Hooven, III (M), John R. Kearfott (J), Arthur T. Lewry (J), Lawrence Sherman Lodewick (J), Otto Alfred Ludecke (J), James F. Machen (J),

Continued

New Members Qualified

Continued

Dudley Lisle McCully (J), James F. McKenna (J), Richard G. Mosher (M), Darwin E. Rightmire (M), Edward J. Russel (J), William E. Schulz (J), Bart L. Seymour (M), John F. Skiff, Jr. (J), Cyril C. Tracey (A), Robert A. Wilkins (M), Russell J. Woodruff (A), Conrad D. Woods (J), William Fong Yee (J).

Indiana Section

Ronald L. Alt (J), Robert A. Chester (J), Kenneth Dehan (J), Carl W. Eddy (J), Richard Wayne Paxson (J), Claude Leon Raymond Renondin (M), William Chas. Stoltenberg (A).

Kansas City Section

John Suprock (M), H. H. White (A).

Metropolitan Section

Edward Bruce Belason (J), Charles B. Brown (A), Frank N. Doherty (A), Robert Jerome Doyle (J), Ed Fleischnich (M), Joseph Galbraith (M), E. Paul Kovac (M), Nicholas Kulba (M), Robert J. Lasky (J), Richard S. MacCrea (A), Michael James Perillo (A), Frank G. Preyer (M), Robert Martin Reithner (A), Leopold Strauss (M), Marvin W. Wainwright (M), Gerson Zweighaft (J).

Mid-Continent Section

Charles S. Parker, Jr. (M).

Mid-Michigan Section

Marwood Mathew Frank (J), Harry R. Schaal (J), Richard B. Thomson (A), Herbert Frederick Thrun (J).

Milwaukee Section

Gordon Dean Kelly (M), Richard Rademacher (J), Ernst Carl Sauerman (J).

Mohawk-Hudson Section

John C. Rabetz (M).

Montreal Section

Marcus Stanley Chappell (J), R. A. Esmonde (M), Peter John Neild (J), Joseph Colman Plucinsky (J).

New England Section

Robert M. Burke (A), Wallis N. Fisher (A), Edward Joseph Goldman (J), Samuel Lack (A), Raimund F. O'Brien, Jr. (M), Charles G. Cameron (A), Raymond M. Sears (M), William R. Wayman (M).

Northern California Section

Joseph A. Belaire (A), E. Clair Hill (M), Gerald R. Holly (M), William F. Kerr (A), John L. Moyer (A), Louis Joseph Petralli (J).

continued

New Members Qualified

Continued

Northwest Section
Gilbert Wittlin (J).

Oregon Section
Harry J. West (A).

Philadelphia Section
Fernando Albert Pellicciotti (J), Robert Schmitz (J), Charles F. Walsh (A), William A. Wild (M), John William Yaag (J).

St. Louis Section
Timothy Martin Cross (J), Dick Q. Durant (J), Gerald W. Hicks (J).

Salt Lake City Group
John E. Medosch (A).

San Diego Section
David S. Hackley (J).

Southern California Section
A. William Brown (M), Heinz J. Gross (J), Edgar Jerome Jones (J), R. A. Le Maitre (J), Duncan Albert Puett (A), William David Rittenhouse (J), Thomas H. Smith (A), Ronald Van Delden (J).

Southern New England Section
Erwin Mooney (A), Thomas P. Nagle (A).

Syracuse Section
John Patrick Paling (J).

Texas Section
Emil E. Friberg (J), Raymond V. Gorman (M), Harvey Dean McElhaney (J), James Michael Nedzbala (J), John J. Segreto (M), Raymond Edward Vache (J).

Texas Gulf Coast Section
Jerry Stephen Graul (J), James A. Haney (J), Roy James West (J).

Twin City Section
Charles Milnar (M), Theodore H. Olson (M).

Western Michigan Section
Clarence N. Bouman (A), William G. Jacobitz (J).

Outside Section Territory
Jerry Henzl (M), Bobbie Joe Martin (J), Noah M. Norman (M), Albert Neal Perry (M), William L. Rumgay (J), Lt. Alexander E. Waller (M), William Frederick Wilson (M).

Foreign
Anastasios S. Halkides (J), Venezuela; Major Mohammed Asim Mirza,

Continued

From **CLEVELAND** . . .

A Revolutionary New Center Bearing Assembly!

Proved by independent tests to be far superior to any center bearing now on the market

Now available as original equipment for trucks and buses, the New CLEVELAND Center Bearing Assembly offers these important advantages:

1. CLEVELAND's exclusive use of a roller bearing, instead of a ball bearing, permits longitudinal sliding action between the roller bearing and the induction-hardened spline shaft. This eliminates any unwanted load on the center bearing and assures low noise levels, minimum wear and long life.
2. CLEVELAND's new design absolutely eliminates center bearing "shudder". Also, it eliminates longitudinal misalignment problems between frame and bearing bracket.
3. CLEVELAND's Center Bearing Assembly embodies a conventional type grease fitting and lubrication channels to permit a complete flushout of any injurious road dirt.

Write for information on this remarkable new product. It's the answer to center bearing problems.

Since 1912

Cleveland Steel Products Corporation

Automotive Division

16025 Brookpark Road, Cleveland 11, Ohio

Universal Joints • Propeller Shafts
Power Take-Off Joints
Center Bearing Assemblies

New Members Qualified

Continued

Ret. (M), India; V. Saravana Perumal (M), So. India; Norbert Nissan Reis (A), Israel; Prof. Ir. H. C. A. van Eldik Thieme (M), Holland.

Applications Received

The applications for membership received between September 10, 1958 and October 10, 1958 are listed below.

Alberta Group

Arthur Hollings, Rene J. Trudel

Atlanta Section

Meldon Frank Hurlbert

Baltimore Section

Frank E. Curran, Jr.

British Columbia Section

Robert Hugh Morris

Buffalo Section

Louis N. Friol, Ernest R. Hugenbruch, William H. Jackson, George T. Miller, Jr., Harold H. Waite

Canadian Section

Lloyd Brian Bender, Gordon McKay Break, Eric Donald Broger, Lennard Maurice Brown, Lawrence Harvey Iron, Colin Lister James, W. H. Mason, Richard Graham Stewart, James W. Ussher

Central Illinois Section

Duane E. Beals, Marvin E. Beyers, Paul Harold Brandes, Donald R. Crews, Richard Albert Day, Leonard F. Dickeson, Ernest Duane Duvall, Glen A. Glover, Jr., Carroll G. Hakenson, Merwyn Dean Leckbee, Normand Robert Rollins, Hwa-Juh Shen, Glenn Eldon Stewart, Carl J. Szentes, Jr.

Chicago Section

John P. Behanna, Arthur R. Blank, George F. Boltz, Kenneth E. Clausen, David M. Cowan, Robert William Gallagher, Roger L. Hoyt, Richard William Kenngott, Gordon L. Kibbey, Richard Daniel Miech, David B. Puryear, Darrell R. Schuldt, Robert F. Shankwitz, Howard C. Shaw, Jr., Frank J. Simak, James L. Thompson, Jr., Robert J. Ullstrup, James Clifford White, Jr.

Cleveland Section

Tadeusz Budzich, Frank Davenport, John E. Foerst, Eugene Hervey, Raymond Holanda, John R. Hydock, Frank Kadyszewski, Erwin Edward Kempke, Jr., Paul Laverne Newhouse, John P. O'Donnell, John R. Poyser, Jr., Ross E. Stewart

Colorado Group

John Welsh Robinson

Dayton Section

L. James Boude, James William Miller, James C. Rine, Jr., Harry Andrew Syak, James Edgar Valentine

Detroit Section

Jalil Uddin Ahmad, Rodney W. Alexander, Edward F. Austin, Ward P. Barnes, Floyd C. Biggs, Raymond B. Boardman, John C. Campbell, William Paul Christiansen, Kenneth L. Clark, Paul A. Clark, Vincent P. Cocivera, Clifford Joseph Collins, Jr., Gerald Alfred Confer, Arnold Irving Cowan, George J. Currier, Richard J. Dalphin, Peter M. Dawson, Benjamin

Continued

Applications Received

Continued

E. Derrick, Paul William Emanuelsen, David R. Engstrom, Peter Henry Foss, Richard E. Gallette, Neal H. Gammell, Thomas W. Gillie, Sebastian Joseph Giuffrida, George Richard Glass, John V. Gorton, John T. Grady, Robert L. Graves, Vincent James Graziano, Howard A. Groombridge, Charles Gordon Gunderson, Richard John Hames, Marquis N. Harris, Jr., David Lavern Hart, Carl Arthur Hawthorne, J. Robert Howland, James W. Hutchinson, Richard D. Kendall, Milton Gene Koenig, Kenneth C. Kraemer, Bruce N. Lewis, Throck M. Lowery, Albert G. Lucas, Frederick E. Lueck, James Louis Mason, Richard Dee McKenna, R. W. Pantalone, Theodore E. Peterson, Arnold J. Phillip, Densmore K. Rheaume, George J. Rumford, John Kurt Sauter, Homer M. Swineford, Alan Thebert, A. K. Thomas, Jr., Walter Torbet, John L. Van Becelaere, David W. Vial, Howard F. Voigt, John Curtis Walker, Richard F. Walter, Clinton Todd Washburn, Fred H. Weihs, Thaddeus Frank Zlotek

Hawaii Section

George M. Bell, Alexander G. Budge, Jr., Larry Grant

Indiana Section

Kenneth A. Apple, Thomas Joseph Bertrand, Gerald Leroy Cameron, Curtis T. Cox, Bruce W. Davis, Dale William Driscol, Stephen L. Gaal, Walter A. Gammel, Sr., James Hanen Garrett, Kenneth B. Harmon, C. Edward Johnson, Allan Scott Norris, Orban H. Reich, William A. Vincent, George W. Yount

Kansas City Section

Robert L. Renfro

Metropolitan Section

George Charney, Clark J. Grey, Ira L. Jackson, Carl Edward Klepper, William R. Lozier, Ralph Martin, Jr., Barrie V. Potter, Allan Jay Rodolitz, Paul P. Rosenfeld, Gustav A. Schumacher, Jr., Isaac Stewart, Martin J. Ungar

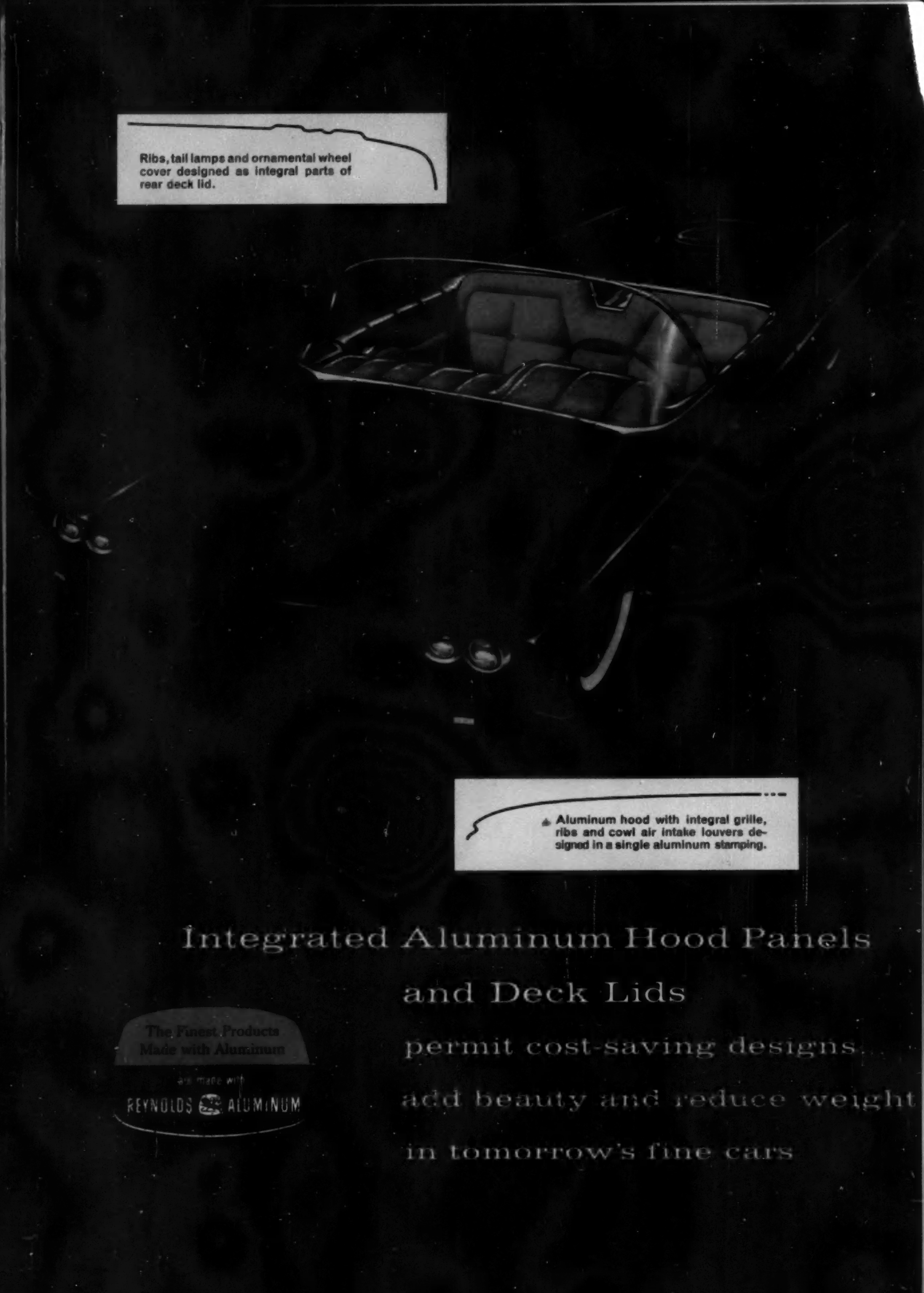
Mid-Continent Section

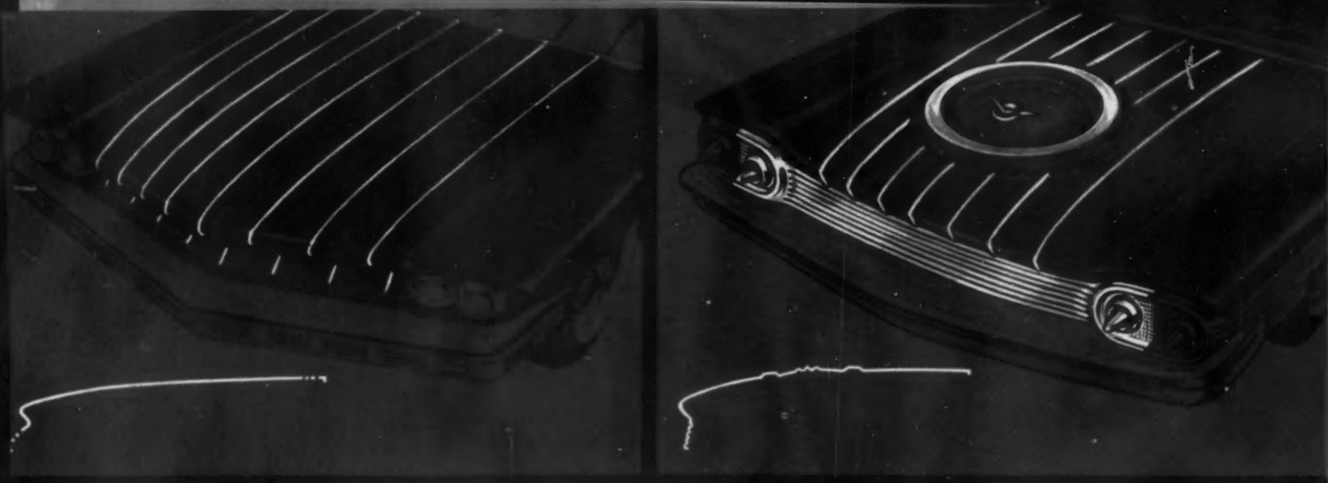
Kenneth H. Yochum

Mid-Michigan Section

Arthur W. Bradley, Lloyd A. Brasseur, A. J. Dunkle, Donald H. Markwood, Tom B. Miller, Richard P. Piefel, Richard J. Rademacher, Theodore F. Ristau, Robert B. Robinson, Melvin A. Schultz, Leonard E. Smith, Kenneth L. Westercamp, Robert Derry Wight

Continued


Ribs, tail lamps and ornamental wheel cover designed as integral parts of rear deck lid.
Aluminum hood with integral grille, ribs and cowl air intake louvers designed in a single aluminum stamping.
Integrated Aluminum Hood Panels and Deck Lids
permit cost-saving designs...
add beauty and reduce weight
in tomorrow's fine cars
The Finest Products Made with Aluminum
are made with
REYNOLDS ALUMINUM



How and why Aluminum and the Integral Design Concept offer important advantages in hood panels and deck lids

As an example of integral design possibilities, illustrated on the front side of this page is an aluminum hood with integral grille and ribs in a *single* aluminum stamping. Following stamping, the bright areas can be brightened chemically or mechanically and the entire panel anodized. The bright areas can then be masked and the panel painted to match adjacent body colors. Paint films adhere remarkably well to anodized aluminum. The excellent forming characteristics of aluminum sheet permit complex stampings which result in increased strength as the metal is cold worked.

Similar techniques and the same general design approach can be employed in the rear deck lid. Stamped ribs can be incorporated in the lid to provide additional stiffening. Script, V-emblems, crests or other ornamentation including tail lamp components and ornamental wheel cover can be included in the stamping die.

This integral concept provides important *cost-reducing* possibilities through the reduction in the number of components normally associated with such construction. Light weight of the panel with simplification of hinging and counter balancing mechanisms is another advantage. And integration also provides cost reduction possibilities by reducing amount of tooling required.

Weight saving is another advantage of aluminum in these body element applications. Weight saved by aluminum panels can run up to 50 to 65%. Aluminum body panels also can reduce overall body weight and lower the center of gravity, thus providing improved performance and stability.

On this type of application and on countless others, Reynolds Aluminum Specialists will be glad to work with you to help you get the very most from the aluminum you use. For details on this service and on aluminum mill products and fabricated aluminum parts and trim, call your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan or P.O. Box 2346-MV, Richmond 18, Virginia.*

NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower *final* cost.

Reynolds Aluminum

the metal for *automation*

TRADEMARK

The Finest Products
Made with Aluminum
are made with
REYNOLDS ALUMINUM

Applications Received

Continued

Milwaukee Section

Gerald W. Bernhoft, J. F. Dindorf, John M. Durham, Robert B. Ewart, Enno A. Gerbitz, Louis C. Haltug, Joseph W. Marchello, Richard George Reinders, Jerome J. Schleis, Milton E. C. Wege

Montreal Section

Bertrand Bouchard, Frederick George Young

New England Section

James Q. Adams, Richard Dawson Cavanaugh, John W. Kastle, Jr., Gareth A. Keith, Justin M. Margolskee, Paul J. Page

Northern California Section

Kazumi Abe, Richard Louis Burkhalter, Richard H. Ferry, Paul Adam Fruehauf, Jr., H. Harry Mueggenburg, Robert B. Rubsamen, Jack Ernest Shinn, Lawrence D. Smith

Northwest Section

John William Bartlett, Donald Dale Christiansen, Robert Dale Crapo, Gerrit William Elsinga, Clare R. Irwin, Charles Duane King, Kaoru Frank Mizuno, Teijiro Namatame

Oregon Section

Wayne E. Fitzpatrick, Ronald E. Meisner

Philadelphia Section

Edwin S. Braun, Evan B. Ewan, Gerald Ginsberg, William Kenneth Greisinger, John F. Hayt, William M. Marcussen, Nelson E. Ockerbloom, Oreste Christopher Quattro, Samuel R. Robb, Harry J. Warmkessel

Pittsburgh Section

William Allen Heinecke, Gerald Edward Price

St. Louis Section

Jordan L. Heiman, Allan Dale Luke, William John Murray, Harry John Sauer, Jr., Geoffry Wallar Smith, George Franklin Wright

Salt Lake Group

George Lydell Jensen

San Diego Section

Daniel Webster Aids, Jr., Alan C. Baker, Wilton R. Dortch, William Walter Fox, Wesley E. Kauder, Roy Bernard LeMaster, Richard L. Lewis, Billy Dean Mahin, A. H. Riley, Jr., B. Eugene Roberson, Wolfgang Rockenhauser, Wesley T. Shipway, Gordon J. Twa

South Texas Group

Norton B. Hargis

Southern California Section

Robert A. Bailey, Harlan Clark Ballentine, Warren P. Boardman, Jr., Dale G. Carey, Robert S. Carleton, James Chew, Hiram J. Coe, Jr., Eldon George Cutler, Richard A. Dudek, Charles L. Dummer, Robert L. Embry, Francis Eshleman, Gerald Duane Foster, Elliott A. Green, Max V. Greeven, David W. Grimm, Joseph B. Gunn, Harris J. Howard, Stanley Ralph Huddleston, Nathan Lockman, Richard H. Luferacki, William A. MacFarland, Owen J. McCaughey, James D. Moore, Jerry L. Moredock, Emilio Peter Muras, Raymond H. Nickerson, Roy D. Nickerson, Jr., Edmund J. Osten-

Continued

Applications Received

Continued

dorf, Jr., Gerald D. Potter, Harry Michael Reid, Gerald David Ritland, Robert J. Sampson, Edward Andrew Scheb, John A. Schroth, Wilfred H. Shaw, Avery Sloan, John Lang Smith, Ray Mace Smith, Paul A. Supancich, Bernard van Aalst, Jr., Filiberto Vargas, Michael Voytish, Jr., James G. Weldon, John F. Yocom, Eugene B. Zwick

Southern New England Section

Richard G. Bartram, Gerald F. Crowley, Donald V. Gervais, David A. Reisman

Syracuse Section

Horace Hugh Christensen, Joseph W. Poliseo

Texas Section

Roger Edward Davidson, James J. Metzer, Jack Robinson, Jr., Jack M. Stuart

Texas Gulf Coast Section

David Lawrence Crowell, Robert E. Pate

Twin City Section

Donald K. Mayer

Washington Section

James Costantino, John Augustine O'Keefe, Jr.

Western Michigan Section

David L. Mayrose, Harvey J. Meeusen

Outside of Section Territory

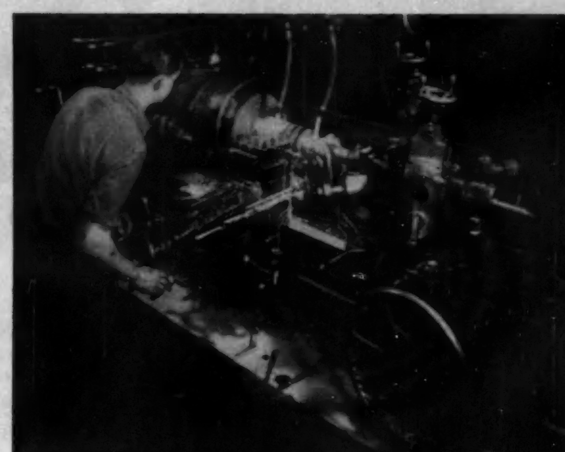
Elton W. Avery, Floyd A. Derby, H. G. Gilchrist, Garnet L. Gillespie, Harold J. Hennig, B. Thomas Horace, Ralph Ernest Jennings, Clyde Oliver Johnson, Henry John Kinsey, John Beam Olinger, Jr., Jerrold R. Owens, Maynard Walter Slack, Frank J. Strnad, Merrill Tate, Homer D. Witzel

Foreign

Rohan S. Amarasinha, Ceylon; Gualterio A. Biberschick, Brazil; Giovanni Bonmartini, Italy; Colin Eric Faulks, Australia; Omkar Nath Fodar, India; K. S. Ganpati, India; Ferdinand Grumme, Sweden; Charles Guinard, France; Jagdish Chandra Madan, India; Tharavath Madhavan Kutty, India; Charles Nicholas Moir, South Africa; Chand Kishen Muttoo, India; R. Nagarajan, India; K. S. Pillai, India; Sunkavally Rajagopalarao, India; D. V. N. Rama Rao, India; David Clifford Riley, England; Manuel Manas Rodriguez, Mexico; P. S. Subramaniam, India

Metal users, save money!

simplify materials control... standardize manufacturing processes



by standardizing on two alloy steels... 4340 and 4620

4340 THROUGH-HARDENING—Use AISI 4340 for moderate-to-heavy section parts... to get maximum strength, toughness, reliability. It's readily annealed to facilitate machining... can even be machined as heat treated in many cases. Welds readily with normal precautions. Responds reliably to heat treatment.

4620 CARBURIZING—Use AISI 4620 for all except the very heaviest duty carburized parts. It is the steel least apt to distort in heat treating. Case hardens easily with excellent case toughness. Shows uniform response to treating. You can treat mixed furnace loads . . . eliminate a re-heating cycle . . . *save more money.*

AMERICAN STEEL WAREHOUSE ASS'N.

Easy to Get... Both these steels are carried by Steel Service Centers from coast to coast . . . ready for delivery on a "next door" basis. For a list of these sources, write: 67 Wall St., New York 5, N. Y.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK

Naugatuck PARACRIL OZO

THE NEW OIL- AND OZONE-RESISTANT NITRILE RUBBER

Naugatuck's challenger for leadership in the field of ozone-resistant, oil-resistant rubber

Compared to the present leading competitive general-purpose oil-resistant, ozone-resistant rubber, Paracril® OZO vulcanizates show *marked superiority* in resistance to oil, fuel and weathering (ozone) and in color retention, abrasion resistance and low moisture absorption. In tensile strength, flame resistance and cost of complete compound, both are essentially the same.

Thus Paracril OZO provides a unique combination of properties far in excess of ordinary nitrile rubber!

But Paracril OZO is no ordinary nitrile rubber! It is a modified Paracril which incorporates the compounding discoveries of Naugatuck research chemists to which reference has been made in recent Paracril advertisements. The chief modifier is one of Naugatuck's Marvinol® vinyl resins, and the product includes excellent stabilizers for both vinyl and rubber.

Paracril OZO is supplied in the form of small, light-colored flakes, permitting easy handling and considerable flexibility in processing methods.

A most important feature of Paracril OZO is that the vinyl resin in it is completely fluxed during its manufacture. This not only eliminates a difficult compounding procedure on the part of the user but also assures full development of the added properties imparted by the vinyl modifier.

Its unique properties particularly recommend Paracril OZO for wire jackets, shoe soles, coated fabrics, automotive parts, hose and belting jackets. Write for Bulletin No. 219 which contains compounding suggestions and interesting test data on Paracril OZO vulcanizates.

Naugatuck Chemical

Division of United States Rubber Company

1140P Elm Street
Naugatuck, Connecticut

US RUBBER

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Rubexport, N.Y.

IMPROVED SWITCHING CHARACTERISTICS!

DELCO HIGH POWER TRANSISTORS OFFER UNSURPASSED PERFORMANCE FOR HIGH VOLTAGE, HIGH POWER APPLICATIONS

TYPICAL CHARACTERISTICS AT 25°C

	DT100	DT80	2N174A	2N174*
Maximum Collector Current	15	15	15	15 amps
Maximum Collector Voltage (Emitter Open)	100	80	80	80 volts
Saturation Resistance	.02	.02	.02	.02 ohms
Thermal Gradient (Junction to Mounting Base)	.8	.8	.8	.8 °C/watt
Nominal Base Current I_B (V_{EC}=2 volts, I_C=5 amps)	135	100	135	135 ma
Collector to Emitter Voltage (Min.) Shorted Base (I_C=.3 amps)	80	70	70	70 volts
Collector to Emitter Voltage (Min.) Open Base (I_C=.3 amps)	70	60	60	60 volts

*Designed to meet MIL-T-19500/13A (Jan) 8 January 1958

HERE IS A LINE OF TRANSISTORS SPECIALLY DESIGNED FOR SWITCHING APPLICATIONS.

Check your switching requirements against the new characteristics of Delco High Power transistors. You will find improved collector to emitter voltage characteristics. You will find higher maximum current ratings—15 amperes. You will find that an extremely low saturation resistance has been retained.

Another important improvement is the solid pin terminal. And, as always, diode voltage ratings are at the maximum rated temperature (95°C.) and voltage.

Write today for engineering data on the *new* characteristics of *all* Delco High Power transistors.

DELCO RADIO

Division of General Motors • Kokomo, Indiana

BRANCH OFFICES

Newark, New Jersey
1180 Raymond Boulevard
Tel: Mitchell 2-6165

Santa Monica, California
726 Santa Monica Boulevard
Tel: Exbrook 3-1465

AGAIN IN '59

GENERAL MOTORS AIR CONDITIONING BY HARRISON COOLS CHEVROLET, PONTIAC, OLDSMOBILE, BUICK AND CADILLAC!

Comfort with a capital "C"! That's what Harrison Air Conditioning† means in the brilliant new 1959 General Motors cars . . . with Custom "under-the-hood" Air Conditioning for *all* GM cars and the thrifty "under-the-dash" Cool-Pack for Chevrolet* and Pontiac. And in winter, passengers can count on snug satisfaction and safety with Harrison heaters and defrosters. Harrison also contributes to peak engine and transmission efficiency with heat control products that range from radiators and thermostats to all types of oil coolers. So, if you have a cooling or heating problem, look to Harrison—makers of top-quality automotive temperature-control products for over 48 years.

†Compressor by Frigidaire *Also available on most 1959 Chevrolet trucks.

TEMPERATURES MADE TO ORDER

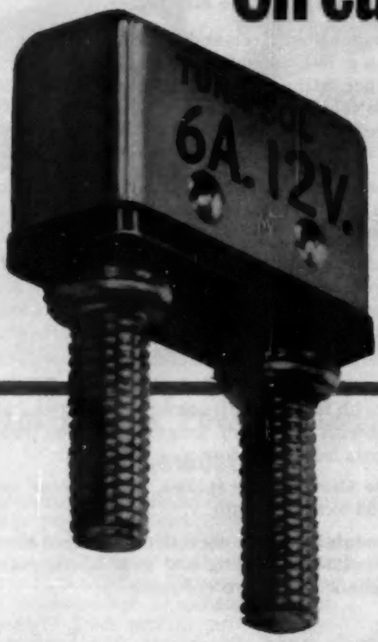
HARRISON

AUTOMOTIVE RADIATORS • OIL COOLERS • THERMOSTATS • AIR CONDITIONERS • HEATERS • DEFROSTERS

GM GENERAL MOTORS

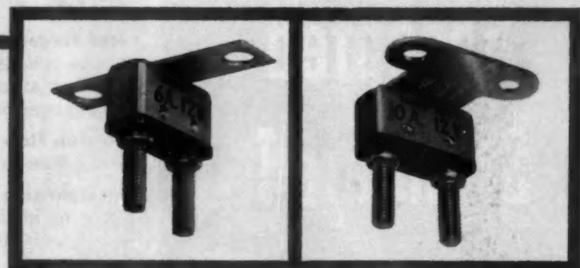
HARRISON RADIATOR DIVISION OF GENERAL MOTORS, LOCKPORT, NEW YORK

Tung-Sol 12-Volt Remote-Reset Circuit Breakers



Positive "Lock Open" Action gives complete protection against:

BURNED-OUT ACCESSORY MOTORS AND WIRING
PERMANENT BREAKER DAMAGE
RUN-DOWN BATTERIES



Standard Mounting Brackets

The Tung-Sol remote-reset type circuit breakers *lock open*, instead of continuing to pulsate, when the circuit is overloaded or shorted. When the cause of the overload or short is removed, the breaker is then remotely reset. It reactivates the circuit within 30 seconds.

Available in 6, 10, 15, 20, 30 and 40 amp. ratings, in a choice of two mounting brackets, Tung-Sol Remote-Reset Circuit Breakers are used in a wide variety of automotive applications. For further information write Engineering Department.

METHOD OF OPERATION

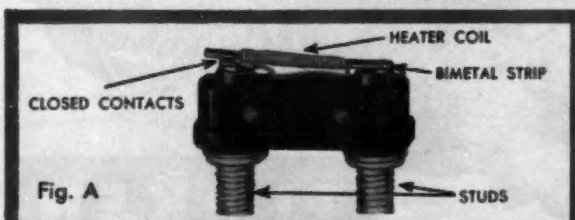


Fig. A

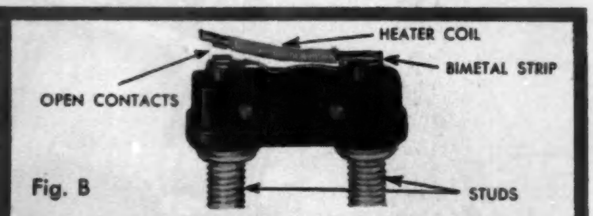


Fig. B

NORMAL CONDITIONS

When circuit conditions are normal, the current flows thru the strip which is attached across breaker studs. When contacts are closed, the heater coil is short circuited and has no heating effect. (Fig. A).

EMERGENCY CONDITIONS

When a short circuit or overload occurs, the increased current causes strip to bend away from contacts. (Fig. B). When the contacts part, the coil is automatically inserted in the circuit.

ELECTROSWITCH DIVISION TUNG-SOL ELECTRIC INC., NEWARK 4, N. J.

SALES OFFICES: ATLANTA, GA.; COLUMBUS, OHIO; CULVER CITY, CALIF.; DALLAS, TEXAS; DENVER, COLO.; DETROIT, MICH.; IRVINGTON, N. J.; MELROSE PARK, ILL.; NEWARK, N. J.; PHILADELPHIA, PA.; SEATTLE, WASH. CANADA: MONTREAL, P. Q.

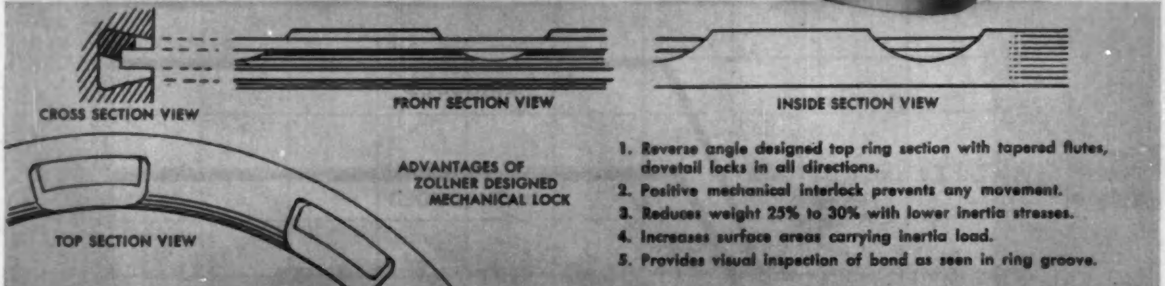
The Piston with "Double Bonded" "Ni-Resist Iron" Top Ring Section STOPS! RING GROOVE WEAR!

BOND O LOC*

Keeps Engines Powerful Longer —at Lowest Cost

"A sensational development — the greatest mileage piston we have ever used." Everywhere, engine builders and transport operators enthuse over the performance of Zollner Bond-O-Loc Pistons. Top ring groove wear problems are eliminated by the "Ni-resist" Iron section *permanently* incorporated with the double bond of *both* A1-Fin metallurgic *and the exclusive* Zollner mechanical lock. Separation failure is impossible. For longer piston life and lower maintenance cost, we suggest your immediate test of Bond-O-Loc advantages.

*T.M. Reg. Pat. App. For



ADVANTAGES OF ZOLLNER DESIGNED MECHANICAL LOCK

1. Reverse angle designed top ring section with tapered flutes, dovetail locks in all directions.
2. Positive mechanical interlock prevents any movement.
3. Reduces weight 25% to 30% with lower inertia stresses.
4. Increases surface areas carrying inertia load.
5. Provides visual inspection of bond as seen in ring groove.

ADVANCED ENGINEERING

PRECISION PRODUCTION

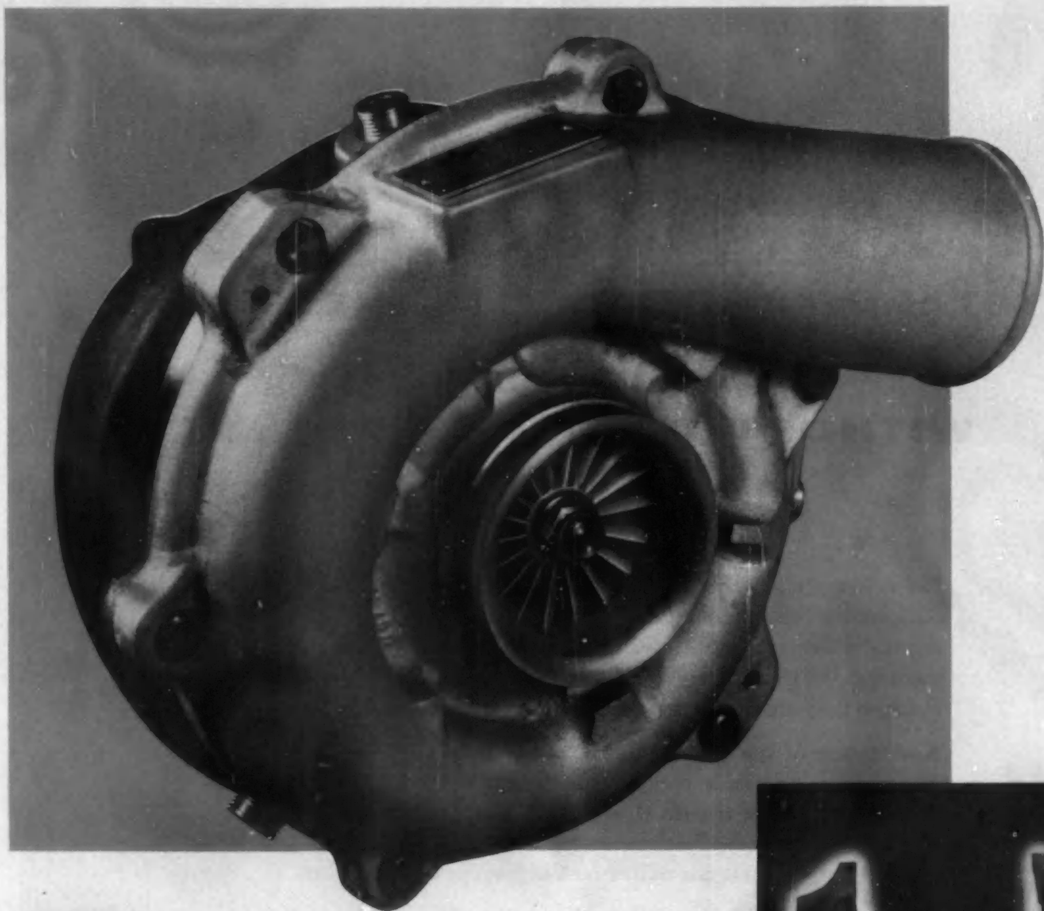
COOPERATION with Engine Builders

ZOLLNER PISTONS

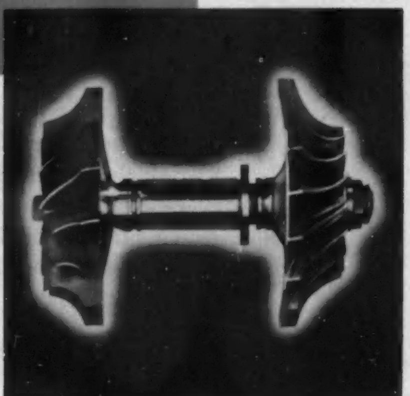
THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER

ZOLLNER CORPORATION • Fort Wayne, Indiana



NEW! Simpler housing and one-piece bearing reduce maintenance on Thompson Turbocharger



Designed for 10,000 operating hours under the severest operating temperatures and speeds. This means longer revenue runs between scheduled maintenance of the unit, and fewer unscheduled downtimes for repairs.

Turbine housing of the new Thompson Turbocharger is a heat-resistant alloy designed to eliminate corrosive attack and to be free from service cracks. Design also isolates high-temperature exhaust drive from bearing and air-side of turbocharger to increase maintenance-free life.

Bearing is one-piece design, mounted on small diameter shaft to reduce bearing surfaces speed even at high rpm.

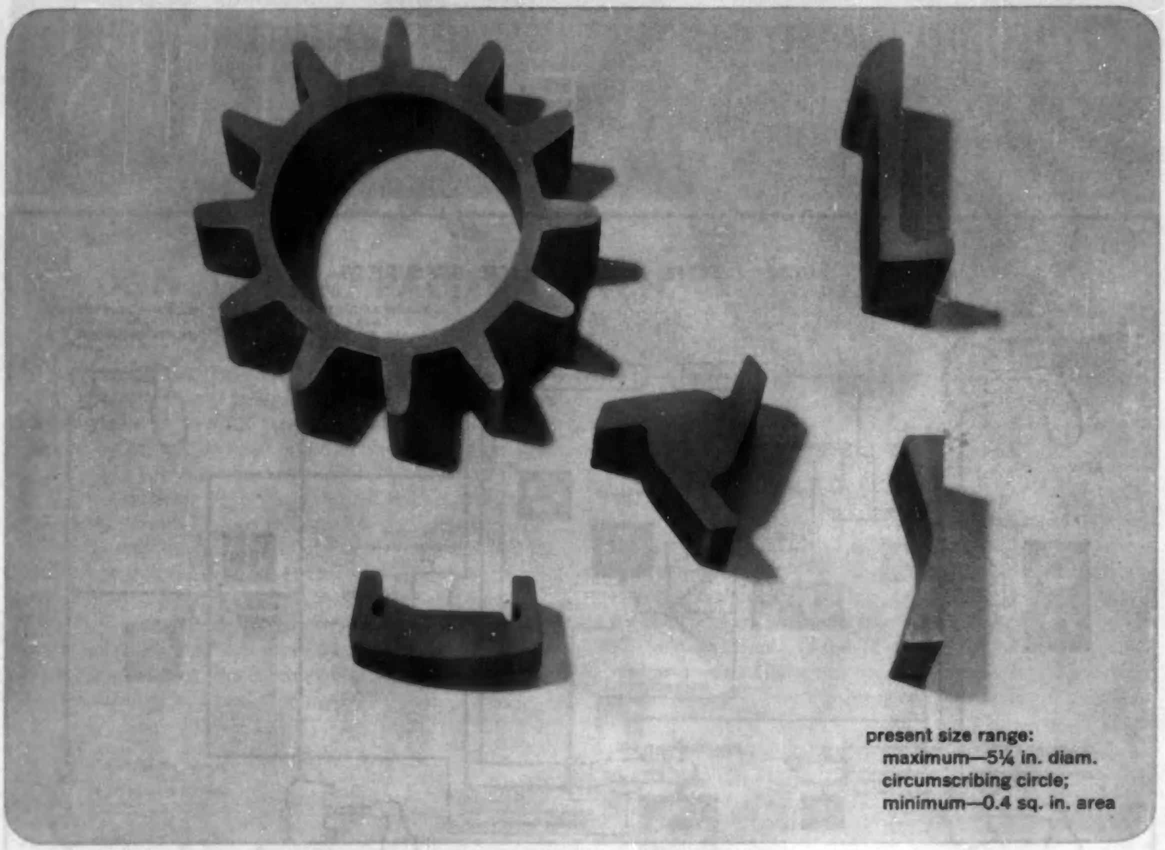
Design of impeller supplies supercharging air at equal compression ratios over a larger flow range and at lower rotor speeds than other turbochargers. Light-alloy rotor provides instant response to changes in engine speed and load.

Your blown diesel engines up to 300 horsepower can be readily equipped with new-design Thompson Turbochargers. Our engineers will help. When may they call?

Write today on your company letterhead for Booklet SJ-1158 which contains technical data on Thompson Turbochargers for blown diesel engines up to 300 horsepower.

TAPCO GROUP
Thompson Products, Inc.
CLEVELAND 17, OHIO

Experience—the added alloy in **A-L Stainless, Electrical and Tool Steels**



- 316 Stainless
- 304 Stainless
- Tool Steel Atlas 93
- SAE 4130
- 410 Stainless

Why hog out intricate shapes like these? **Let A-L extrude them in any steel**

If you're hogging out sections, paying for special mill rolls on small orders, or waiting for minimum rolling mill tonnages, Allegheny Ludlum Steel Extrusions are your answer. They will save you scrap loss, slash your machining costs, hold down your inventory requirements and cut delivery time.

Extruded shapes save money on expensive materials and on costly machining. Non-ferrous applications in the last decade have proven it. Now even greater savings are possible with tough, strong metals in Allegheny Ludlum Steel Extrusions.

Intricate extruded shapes in all stainless grades, tool steels, carbon steels, electrical steels, high temperature alloys, even zirconium and nickel alloys are now in production at Allegheny Ludlum, cutting costs in many different industries.

Costs and minimum order quantities are surprisingly low. Charge for die design is under $200. Orders taken for as little as 40 pounds.

To learn more about the time and cost-cutting possibilities of Allegheny Ludlum Hot Steel Extrusions, send for the extrusion booklet—12-pages of design and engineering information with process and product explanation, material properties, design tips and limitations, tolerances, order instructions, etc. Or call any A-L office for technical assistance. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. SA-11.

WSW 7119

ALLEGHENY LUDLUM

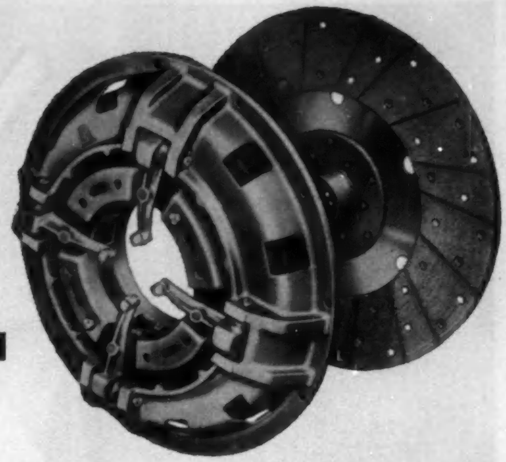
for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Where constant capacity
of equipment counts most . . .

Lipe TC
CONSTANT CAPACITY CLUTCH



Lipe TC Constant Capacity Clutches available in 15½" and 17" Single and Double Plate Sizes—torque capacity range of 715 to 3700 ft. lbs.

Simplicity is the key characteristic of this clutch. No vastly complicated power trains to deadline equipment for days or weeks . . . no $200 tear-downs to replace a $2 part.

Based on an unique application of the toggle principle, the TC gives you full torque capacity *for the entire life of the friction material!* It compensates for fading pressure of expanding springs . . . never loses torque capacity while there is a reasonable amount of friction material left to hold. Rugged linkage construction within the clutch insures long life, parallelism, and smooth engagement.

The high thermal capacity of the TC is provided by the massive plate, ribbed for rapid radiation and cooled by effective currents of air. Internal cooling protects springs from overheating and loss of temper.

Since the automatically compensated pressure eliminates the need for frequent adjustment, the TC has proved one of the least costly of all heavy duty clutches to maintain. A periodic check of clutch pedal "free travel" is all that is required to keep constant tabs on adjustment.

The engagement, of the TC is gentle, chatter-free, "soft," — easy on driveline components — assures less down-time, longer life, and lower overall cost per hour of operation.

WRITE for specifications and performance data, proving the TC Constant Capacity Clutch can maintain the constant capacity of your equipment!

Lipe-ROLLWAY CORPORATION SYRACUSE 1, N.Y.

MANUFACTURERS OF AUTOMOTIVE CLUTCHES AND MACHINE TOOLS

New design in Sigma hand welding torches

Here is a new, lightweight torch—only 16 ounces—for manually welding light-gage steels. Sigma ST-2 welds in all positions with no change in control or current settings. Welds .030- to .100-in. sheet, using low-voltage short-arc technique with .020- and .030-in. hard-drawn wire. For 200 amp continuous service, a-c or d-c.

Balanced design makes handling easy. Service lines enter through rear of handle—a convenience in cramped quarters. Start-stop switch on handle, easy to reach. Nozzle has a 60° curve for maximum weld visibility.

Sigma ST-2 makes high-quality welds at high speed. Seams require no cleaning . . . distortion is at a minimum. Inert gas shielding is economical. Low flow rate—only 10 cu. ft. or less per hour—means even more savings.

Call your nearest LINDE office today for a demonstration of this new Sigma ST-2 torch! Or write Dept. SA11, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE


What the eye would see on the other side of the moon has intrigued and defied the imaginations of scientific minds for centuries. But there's another way to look at moon trips—from a very much down-to-earth point of view. The Space Age is built upon the ingenuity and capabilities of American scientists and engineers who have solved the myriad problems of the space arts—propulsion, stabilization, and control of launching vehicles—and the transmittal, reduction, and analysis of data so that man can comprehend the scientific import of his achievement. The Telecomputing Corporation, through the specialized activities of its six divisions, has contributed significantly to advancements in each of these areas of the space arts. Look to the skills, experience, and facilities of Telecomputing for the solution of your control and data processing problems. Write today for your copy of the TC story—"Blueprint For Progress."
ANOTHER WAY TO LOOK AT IT
DIVISIONS AND SUBSIDIARIES
OF TELECOMPUTING CORPORATION
BE
BRUBAKER ELECTRONICS An R & D leader in the field of ground and airborne IFF components, test & checkout equipments—IFF systems analysis—Air Traffic control systems—radar beaconry—detection equipments.
WG
WHITTAKER GYRO Leading producer of electrically driven and spring-wound free gyros, rate and floated rate gyros for advanced missile systems—rate of roll, pitch, and yaw indicators for manned aircraft—bank and turn indicators.
DI
DATA INSTRUMENTS Pioneers in equipments for fast and accurate analysis of test data, with automatic recording of punched cards, tapes, or printed lists—for aircraft and missile flight tests, industrial and scientific applications.
ES
ENGINEERING SERVICES Specialists in rapid, accurate reduction and evaluation of military and commercial data. Currently handling data reduction for daily missile firings at Holloman Air Force Base.
WC
WHITTAKER CONTROLS The largest developer and builder of custom-built high-performance hydraulic, pneumatic, and fuel valves, controls, and regulators for advanced missile, aircraft, and industrial applications.
NI
NUCLEAR INSTRUMENTS Designers and builders of high quality, reliable equipments for prelaunch checkout and testing of nuclear special weapons.
TELECOMPUTING CORPORATION
915 North Citrus Ave., Los Angeles 38, California
TC

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

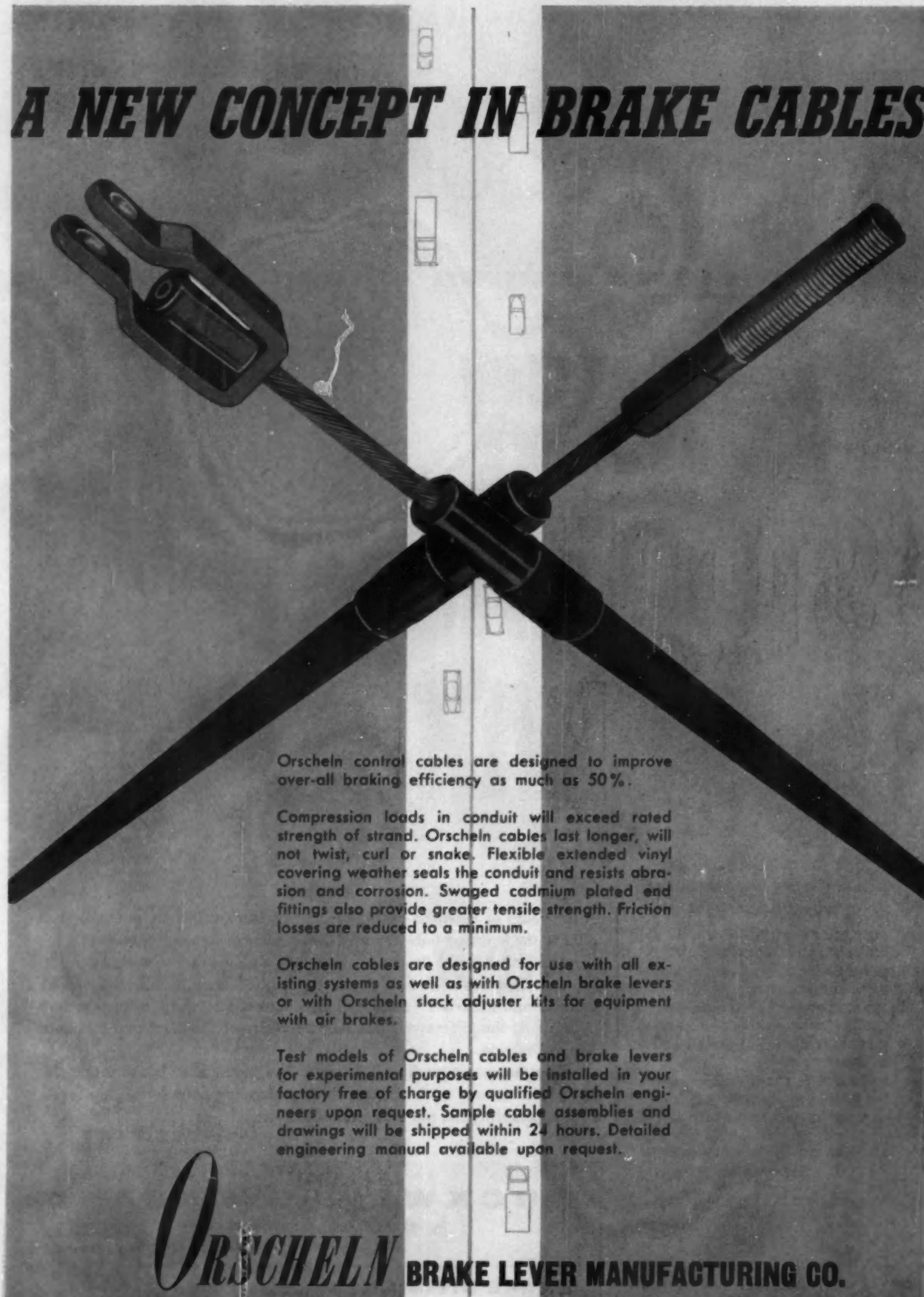
President, Douglas Aircraft Company

In this fast-moving age we find that we can no longer insure leadership... or even survival... by doing things the traditional way. If there's a better way, we must find it.

Our DC-8, C-133, Thor, Nike-Hercules, Genie, Sparrow and other aircraft and missiles are all the finest of their type and time. But their success, and that of our many new projects, depends on superior engineering.

That's why I'm looking for engineers dedicated to quality work. Only through such dedication can the extra performance and reliability of our products be attained. If you feel as we do about this principle, we'd certainly like to hear from you in regard to a future at Douglas.

Write to Mr. C. C. LaVene,
Douglas Aircraft Company, Box 620-O
Santa Monica, California

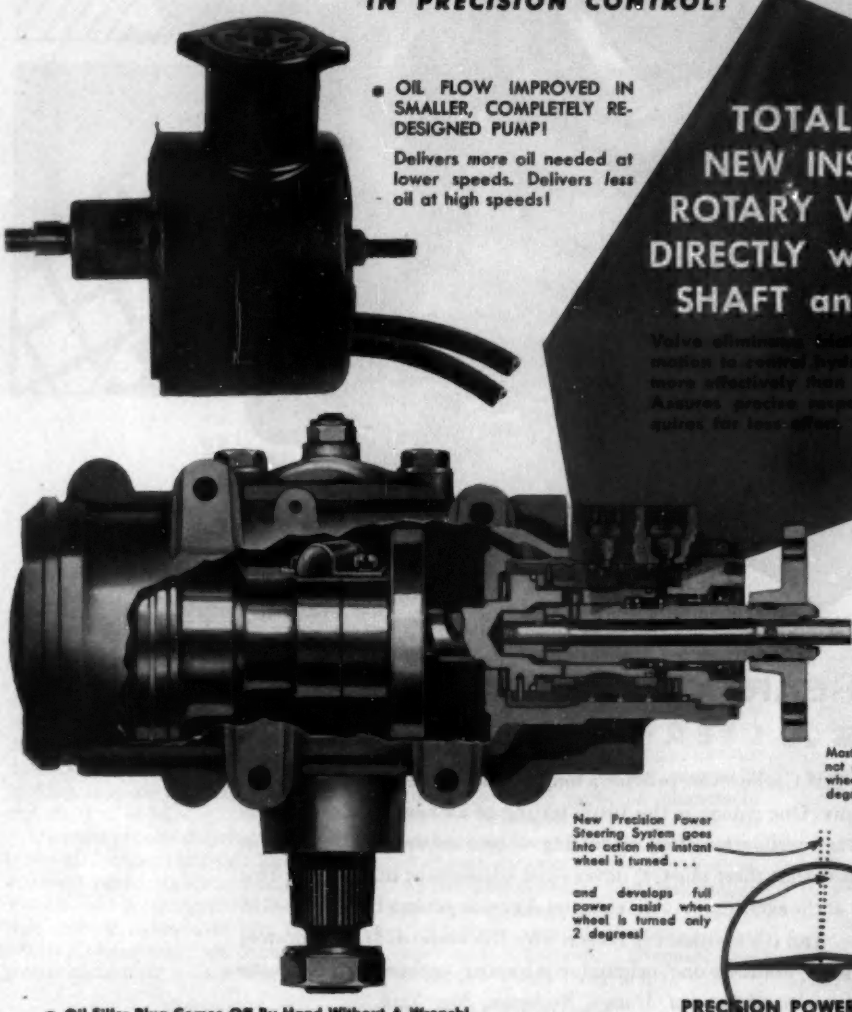

A NEW CONCEPT IN BRAKE CABLES
Orscheln control cables are designed to improve over-all braking efficiency as much as 50%.
Compression loads in conduit will exceed rated strength of strand. Orscheln cables last longer, will not twist, curl or snake. Flexible extended vinyl covering weather seals the conduit and resists abrasion and corrosion. Swaged cadmium plated end fittings also provide greater tensile strength. Friction losses are reduced to a minimum.
Orscheln cables are designed for use with all existing systems as well as with Orscheln brake levers or with Orscheln slack adjuster kits for equipment with air brakes.
Test models of Orscheln cables and brake levers for experimental purposes will be installed in your factory free of charge by qualified Orscheln engineers upon request. Sample cable assemblies and drawings will be shipped within 24 hours. Detailed engineering manual available upon request.
ORSCHELN BRAKE LEVER MANUFACTURING CO.
MOBERLY, MISSOURI

GENERAL MOTORS

Announces

A COMPLETELY NEW SYSTEM OF PRECISION POWER STEERING AVAILABLE EXCLUSIVELY ON 1959 GENERAL MOTORS CARS!

A REVOLUTIONARY ADVANCE IN PRECISION CONTROL!



- **OIL FLOW IMPROVED IN SMALLER, COMPLETELY REDESIGNED PUMP!**

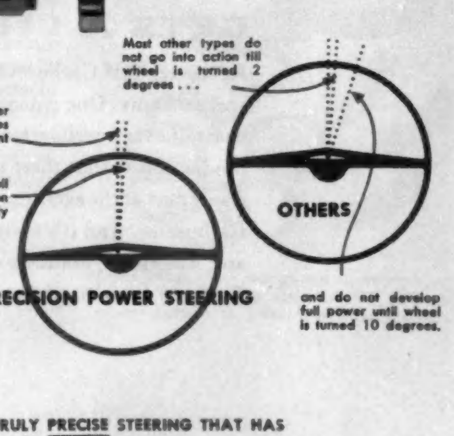
  Delivers *more* oil needed at lower speeds. Delivers *less* oil at high speeds!

TOTALLY NEW INSTANT-ACTION ROTARY VALVE ROTATES DIRECTLY with STEERING SHAFT and WORM!

Valve eliminates friction and lost motion to control hydraulic power more effectively than ever before! Assures precise response yet requires far less effort.

- **UP TO 5 TIMES GREATER HANDLING EASE THAN COMPETITIVE TYPES!**

  Normal parking requires only 2½ pounds of effort! Actually *improves* natural "road feel" vital to safe, relaxed control!



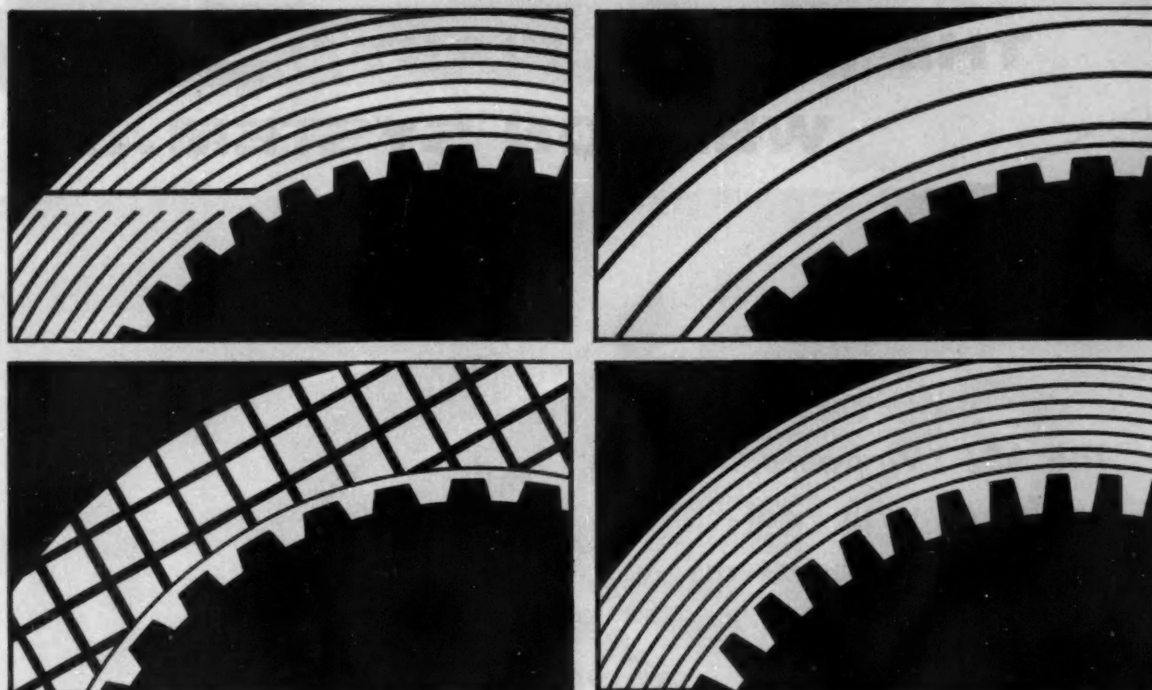
- **Oil Filler Plug Comes Off By Hand Without A Wrench!**
- **Seventeen Fewer Parts and One Pound Lighter Than Previous Model!**
- **Eliminates Ten Oil Seals to Minimize Servicing Problems!**

THE RESULT IS "PINPOINT PRECISION" HANDLING EASE . . . THE TRULY PRECISE STEERING THAT HAS ALWAYS BEEN THE GOAL OF AUTOMOTIVE ENGINEERS . . . PLUS THE EASE AND SAFETY OF POWER ASSIST!

Saginaw POWER STEERING

SAGINAW STEERING GEAR DIVISION · GENERAL MOTORS CORPORATION · SAGINAW, MICH.

ANOTHER EXAMPLE OF HOW CONTINUING RESEARCH KEEPS R/M FIRST IN FRICTION



How R/M grooves friction material to give you better performance at lower cost

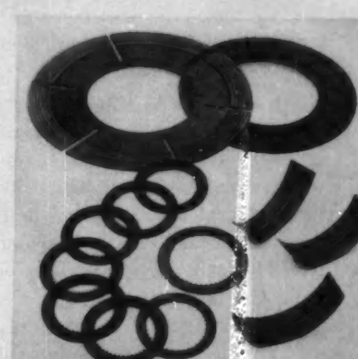
Putting grooves in friction material is a relatively simple operation that can produce some highly complex results.

Friction material—clutch facings, automatic transmission discs, brake linings—may be grooved for a variety of different reasons: to dissipate heat, reduce wear, improve engagement, prevent sticking, increase friction, direct or control the flow of oil.

Different groove patterns in different types of friction materials give widely different performance characteristics. Yet the *same* groove patterns in different type materials may also give different results. Consequently, choosing the best groove pattern for a friction application can be a very hard—and important—job.

Unlike other manufacturers, R/M works with *all* types of friction materials. So you can be sure of a completely unbiased recommendation when you consult an R/M engineer. Constantly testing, exploring, developing in advance of the day's needs, we are constantly finding new and profitable answers to friction problems. We may have the answers to those you are facing now. And with our sales engineers in the field, we can have a man at your desk on any problem within 24 hours.

Whatever your requirements, whatever your application, whenever you think of friction, think first of R/M.



Brake linings, clutch facings, and automatic transmission discs showing some of the different groove patterns for better friction performance.

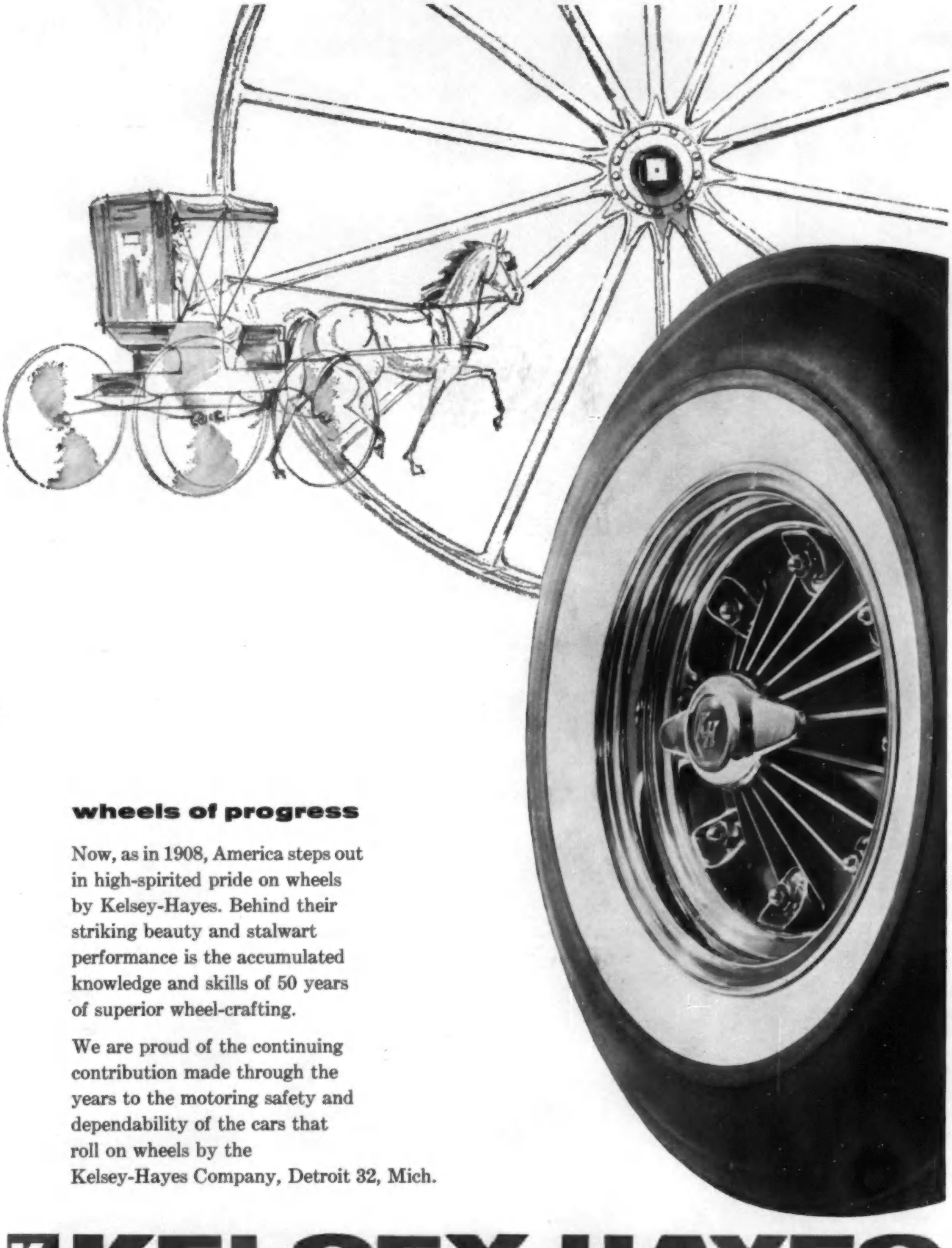
Write now for free catalog. It is loaded with practical design and engineering data on all R/M friction materials.

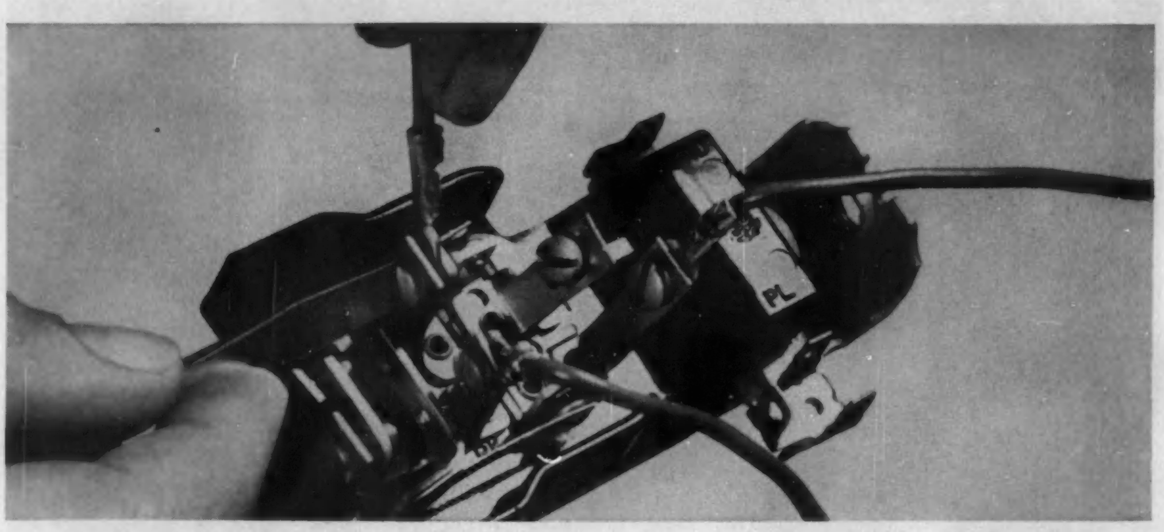
R/M FIRST IN FRICTION

RAYBESTOS-MANHATTAN, INC.

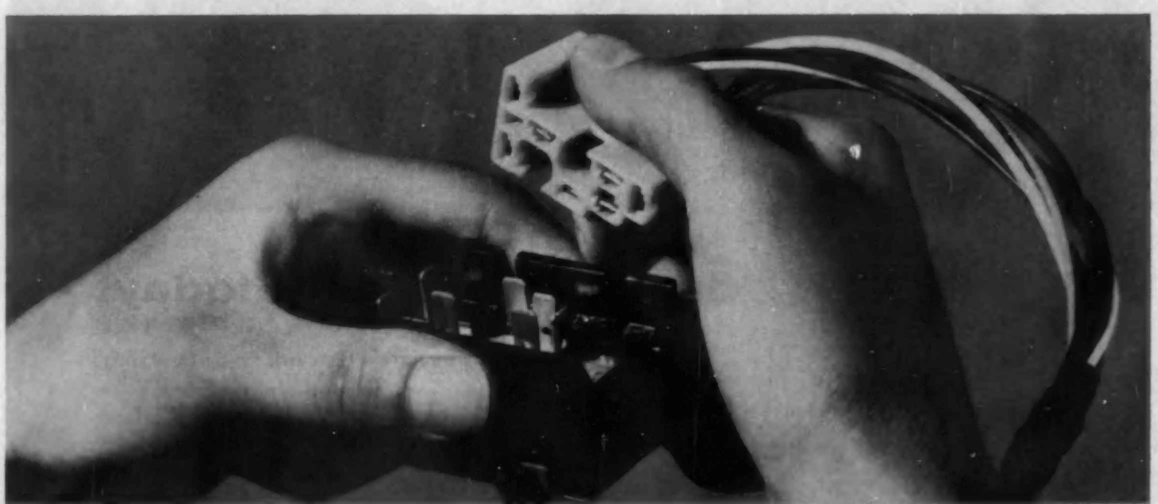
EQUIPMENT SALES DIVISION: Bridgeport, Conn. • Chicago 31 • Cleveland 16 • Detroit 2 • Los Angeles 58

RAYBESTOS-MANHATTAN, INC., Brake Linings • Brake Blocks • Clutch Facings • Sintered Metal Products Industrial Adhesives • Mechanical Packings • Asbestos Textiles • Industrial Rubber • Rubber Covered Equipment • Engineered Plastics • Abrasive and Diamond Wheels • Laundry Pads and Covers • Bowling Balls





SLOW / *All these movements*



SWIFT / *can be reduced to one!*

One simple movement can connect two, three, five—up to eight different electrical circuits. Automakers prefer the Packard Electric idea of "Snap Fast" connectors because they speed wiring installations, save pennies per car. And these multiple-connection, self-insulating units assure accuracy, too. Since they can't be improperly installed, they eliminate the danger of assembly-line fires or other damage which often result from mistakes in single-terminal installations.

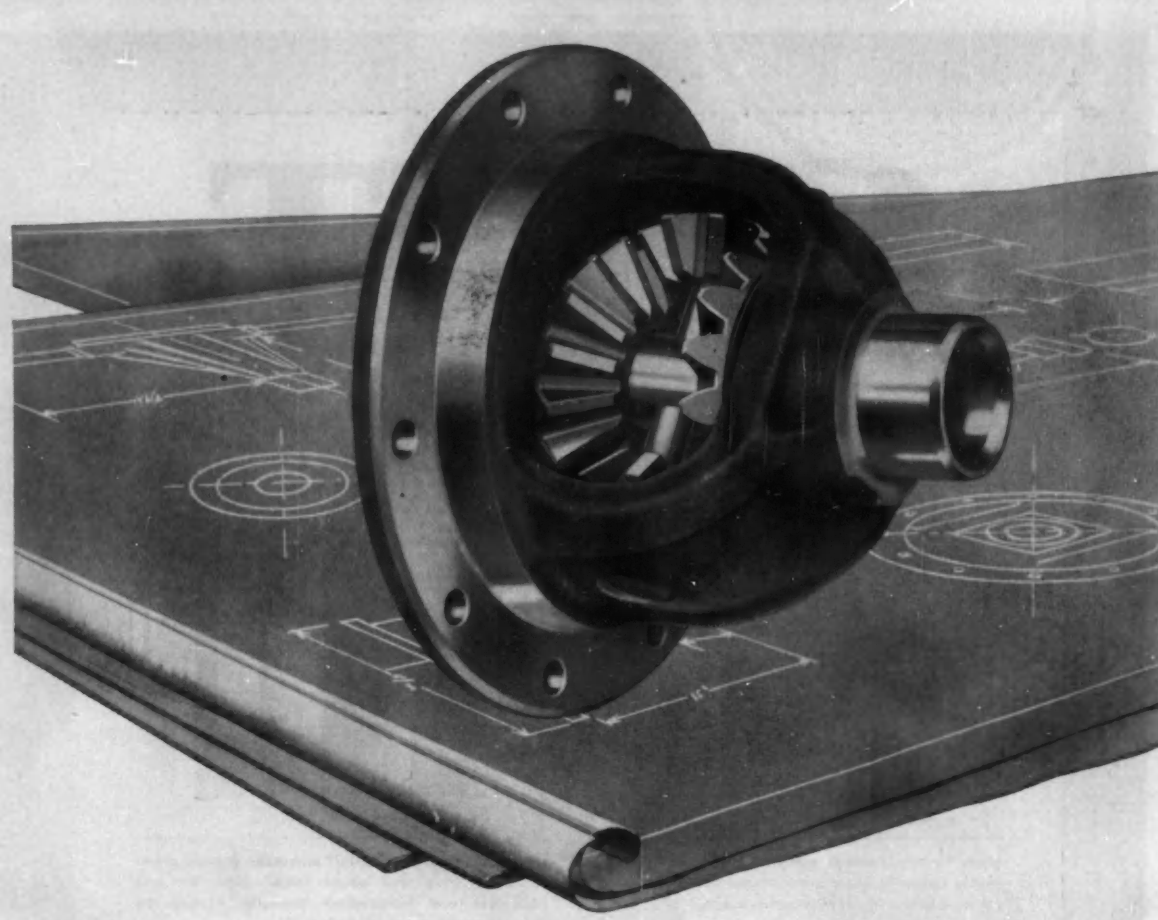
Designing time-saving, high-quality wiring systems and supplying them in large quantities is a long-time habit with Packard Electric. Many manufacturers prefer having one source, one responsibility, one transaction for their electric cable needs. And they find Packard engineering consultation helpful, too. Packard Electric maintains offices in Detroit, Chicago, and Oakland, California.

Packard Electric

Warren, Ohio

GM GENERAL MOTORS

"Live Wire" division of General Motors



Save the cost of tooling up! . . . Specify Spicer components in your new axle design

The easy, economical way to design even the most unusual new axle is to build it around one or more Spicer components...this stock differential assembly, for example.

So why not recheck your blueprints? 9 out of 10 times you'll find Spicer can deliver just the differential assembly you need for your latest front or rear driving axle . . . at a fraction of the cost of producing a new design.

What's more, samples can be obtained quickly for any new development program.

The easiest way is to contact your Dana representative. He'll be glad to match up any number of Spicer axle components to create . . . at the lowest possible cost . . . just the axle you have in mind..

Spicer also has a line of rear and front driving axles with load carrying capacities from 1000 to 7500 lbs.

Be sure to write for Bulletin No. 364. It gives you all the dimensions you need to start designing with Spicer differential assemblies.

DANA
Spicer

DANA CORPORATION • Toledo 1, Ohio

DANA PRODUCTS Serve Many Fields:

AUTOMOTIVE: Transmissions, Universal Joints, Propeller Shafts, Axles, Powr-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

INDUSTRIAL VEHICLES AND EQUIPMENT: Transmissions, Universal Joints, Propeller Shafts, Axles, Gear Boxes, Clutches, Forgings, Stampings.

AVIATION: Universal Joints, Propeller Shafts, Axles, Gears, Forgings, Stampings.

RAILROAD: Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives, Forgings, Stampings.

AGRICULTURE: Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

MARINE: Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario.

RIGID URETHANE FOAM INSULATION
passes rugged "road test"!

In use under actual road conditions, rigid urethane foam insulation is rated excellent for all-around performance in refrigerated truck trailers!

It is currently proving its superiority as well in "reefer" cars, home appliances, and industrial, commercial and other refrigeration equipment.

Besides combining insulating efficiency with many practical plus values, urethane frequently costs less installed. Molded, sprayed or foamed in place or worked from slab stock, urethane foam saves production time and labor. Since it adds rigidity, lighter structural materials can be substituted in many applications

If you want to explore the use of urethane foam insulation, our application laboratory can give you valuable assistance. We produce NACCONATE® Diisocyanates, essential components in all urethane formulations.

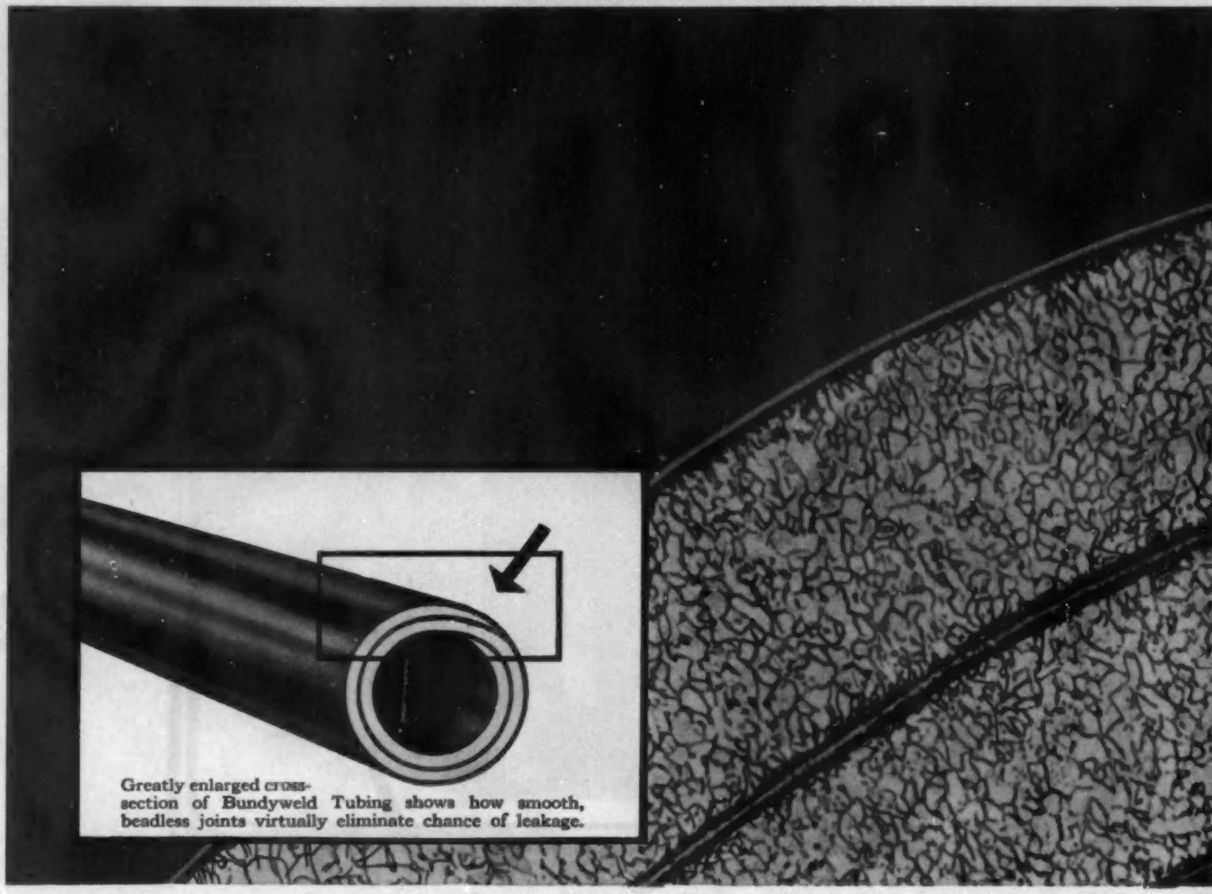
Modular "sandwich" panels of rigid urethane foam, provide complete isolation for truck trailers, eliminating heat loss due to through-metal contacts.

Lightweight urethane retains its high efficiency longer. It has low moisture pick-up, doesn't "pack down" and withstands 250°F. without deterioration. Modular construction facilitates repair and replacement.

NATIONAL ANILINE DIVISION
40 RECTOR STREET, NEW YORK 6, N. Y.
Atlanta Boston Charlotte Chattanooga Chicago Greensboro
Los Angeles Philadelphia Portland, Ore. Providence San Francisco

Allied Chemical

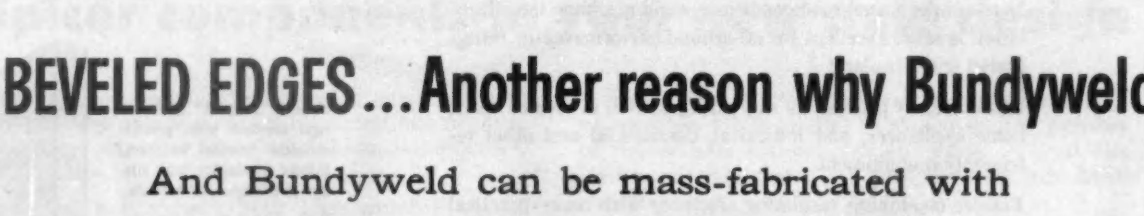
WHY BUNDY LEADS IN MASS-FABRICATION:



Greatly enlarged cross-section of Bundyweld Tubing shows how smooth, beadless joints virtually eliminate chance of leakage.

BEVELED EDGES...Another reason why Bundyweld

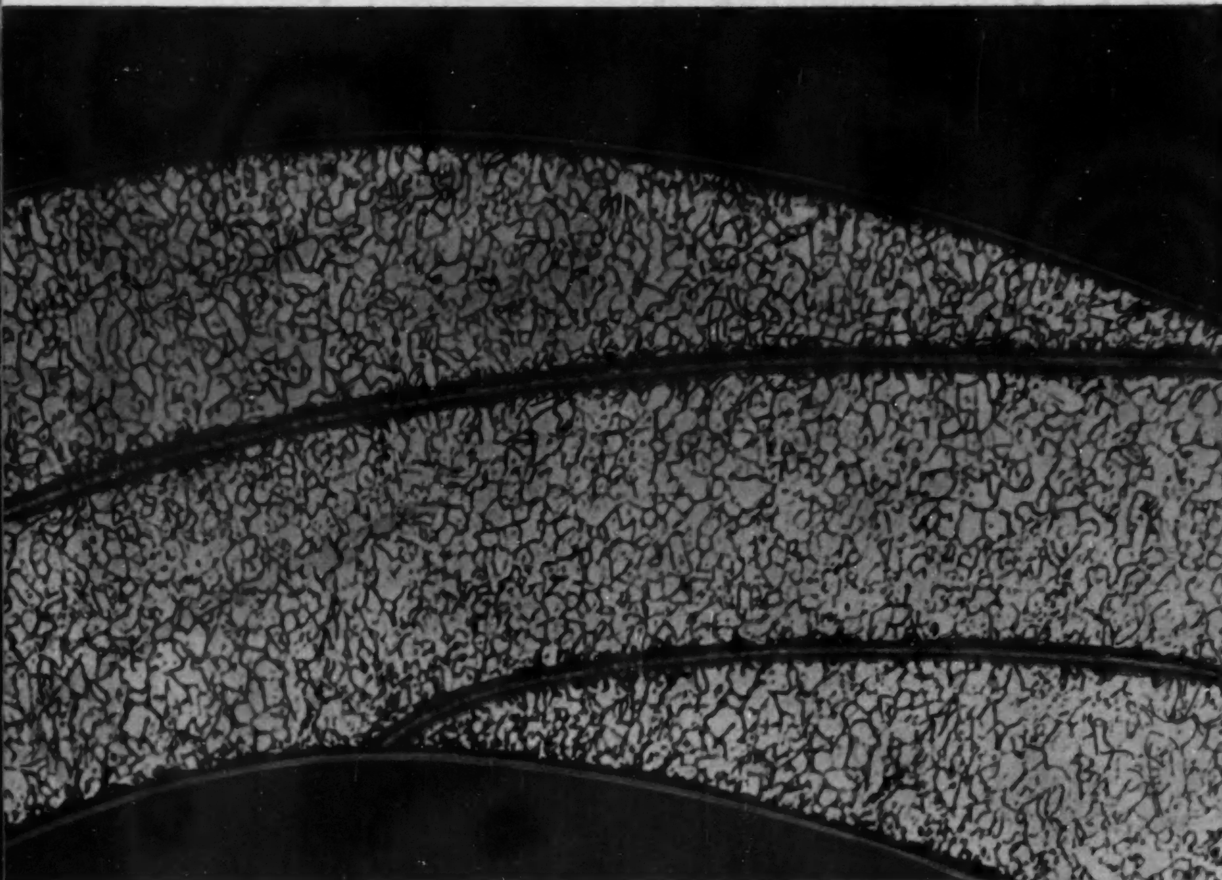
And Bundyweld can be mass-fabricated with speed and precision—at minimum unit-cost because of these Bundy advantages:



Bundyweld starts as a single strip of copper-coated steel. Then it's continuously rolled twice around laterally . . .

into a tube of uniform thickness, and passed through a furnace where copper coating fuses with steel.

Result: Bundyweld Tubing—double-walled, beadless, metallurgically bonded through 360° of wall contact.



is stronger, smoother, easier to fabricate

These Bundy®-developed beveled edges provide smooth, beadless joints, inside and out; insure full, double-walled strength however the tubing is cut or bent. They're *one* reason why Bundy leads in mass-fabrication; here are three more:

Bundyweld® Tubing is double-walled from a *single* strip, copper-brazed for high strength and resistance to vibration-fatigue in fluid-transmission *or* mechanical applications. From brakelines to pushrods, Bundyweld is on 95% of today's cars, in an average of 20 uses each.

Bundyweld designers are on call at any stage in the development of your product. They'll help work the kinks out of knotty tubing problems . . . find money-saving shortcuts with no compromise in function.

Bundy fabricators use special Bundy-designed fixtures and machines to mass-fabricate parts to your specifications, at low unit-cost.

Check *first* with Bundy! You'll get the best in small-diameter tubing, *plus* the finest design and fabrication services available. Call, write or wire us today!

BUNDY TUBING COMPANY • DETROIT 14, MICHIGAN

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING • AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

There's no real substitute for

BUNDYWELD® TUBING

Bundyweld and Bundy specialty tubings are sold through distributors in principal cities

Quality Control is a BORG & BECK tradition that means

BETTER CLUTCHES

At Borg & Beck, quality control is not just a phrase to which we pay lip service. It is a tradition born of the long-standing Borg & Beck policy of building up to a standard —not down to a price.

In the photograph at the left, for example, release levers are being checked on special equipment to make sure they are parallel with the pressure plate. As shown at the right, every Borg & Beck clutch plate is carefully tested for correct deflection to assure positive release. And every driven plate and cover assembly is dynamically balanced for maximum smoothness of operation.

These exacting tests are typical of the extra care that goes into every step in the making of Borg & Beck clutches. They are your assurance of top quality, top performance, top value. And that means: BETTER CLUTCHES.

Reg. U.S. Pat. Off.

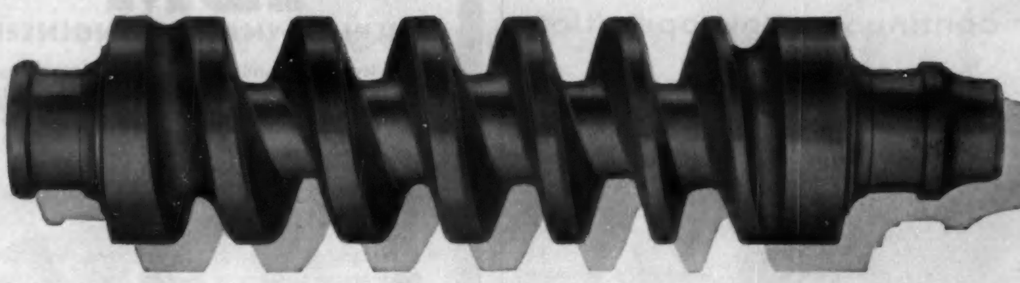
BORG & BECK®

THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

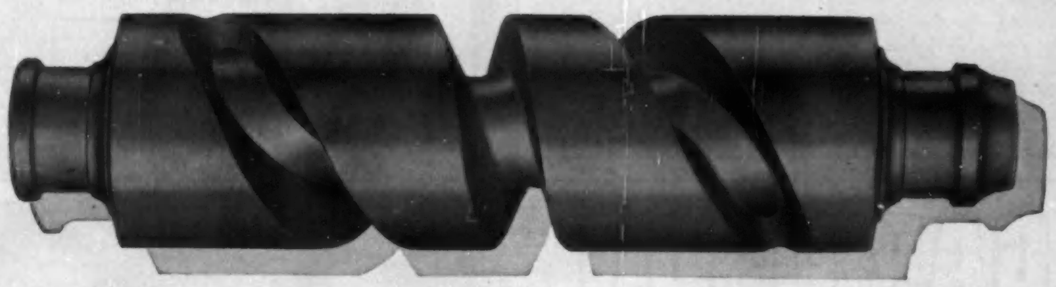
Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3

Tale of Two Steering Cams



▲ **Constant ratio 22:22:22** . . . 22 to 1 ratio for cornering and 22 to 1 for straight-ahead driving . . . 5 turns of steering wheel from lock to lock.

Variable ratio 12:20:12 . . . 12 to 1 ratio for cornering and 20 to 1 for straight-ahead handling . . . 3 turns of wheel from lock to lock. ▼



. . . Constant Ratio and Variable Ratio

▶ Yes, these two cams tell a Ross engineering story of *alert steering response* and *greater maneuverability* for vehicles of many different types:

Passenger Cars	Farm Machinery
Trucks, Buses	Industrial Equipment

▶ The two vastly different cams also help dramatize the fact that Ross provides a gear for every steering need, power or manual, variable or constant ratio. Variable ratio steering was originated and developed by Ross.

▶ Ross invites discussion of *any* steering problem.

Ross

STEERING

ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA

Gemmer Division • Detroit

CLEANABLE DUPLEX FILTER

for continuous flow operation

Continuous liquid flow with extremely fine particle filtration is achieved with Air-Maze cleanable Duplex Liquid Filters. By paralleling two filters through a common header containing a diverter valve, one filter unit handles the full liquid flow while the second filter is being cleaned. Filter media is specially processed metal screen of bronze, monel or stainless, over perforated tube and assembled in a container. Screen openings are precisely controlled to provide various degrees of filtration. Standard Duplex Filters are available for pipe sizes down to ⅛" and in capacities from ½ gpm to 720 gpm at pressures up to 100 psi. Write for Bulletin LFC-556. **AIR-MAZE CORPORATION**, Cleveland 28, Ohio. Dept. SA-11.

IBM

THERMODYNAMICS ENGINEER

Excellent opportunity for thermodynamics engineer with extensive experience in aircraft installation and cooling work. Should have good background in heat transfer, packaging and aircraft structures.

Qualifications

Engineering degree and 3 to 5 years' experience.

Advantages of IBM

A recognized leader in the electronic computer field; stable balance of military and commercial work; advancement on merit; company-paid relocation expenses; liberal company benefits; salary commensurate with ability and experience.

Immediate openings at Owego, N. Y.

WRITE, outlining qualifications and experience, to:

Mr. P. E. Strohm, Dept. 684Y
Military Products Div.
IBM Corporation
Owego, New York

IBM INTERNATIONAL BUSINESS MACHINES CORPORATION

DATA PROCESSING • ELECTRIC TYPEWRITERS • MILITARY PRODUCTS
SPECIAL ENG'G. PRODUCTS • SUPPLIES • TIME EQUIPMENT

GARRISON

POWER STEERING

helps this KENWORTH jockey the BIG ONES!

Handling big tow loads like the Boeing 707 is made to order for this Kenworth Towing Tractor. With Garrison Power Steering on both front and rear wheels even this giant plane is jockeyed like a baby buggy.

On the Kenworth Towing Tractor, Garrison Power Steering provides maximum ease of handling and unusual maneuverability. It supplies a choice of two-wheel steering and four-wheel steering, or oblique (crab) steering merely by changing a selector. With 80% of the effort supplied by the Garrison hydraulic cylinders, operators get jobs done safer, faster, and with less strain on both men and machines!

Ask how your steering problem may be solved for easier operation and greater efficiency with GARRISON POWER STEERING...available for medium and heavy trucks, truck cranes, motor graders, wheeled material-handling, off-the-road equipment and specialized vehicles.

GARRISON *Manufacturing Co. Inc.*

4609 East Sheila Street
Los Angeles 22, California

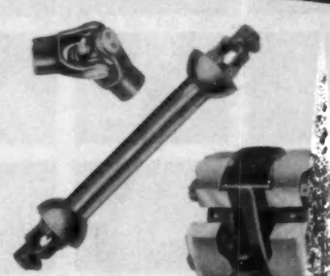
On these rugged products by INTERNATIONAL HARVESTER

Blood Brothers Universals deliver dependable power

PUT YOUR PRODUCT AHEAD—WITH ROCKWELL-STANDARD COMPONENTS

On all these major-product lines, International Harvester uses Blood Brothers Universal Joints. In rigorous daily service, they've proved outstanding ability to *deliver power dependably*. And for I-H, that means customer good-will insurance!

If you build construction, farm or transportation equipment, investigate these Rockwell-Standard components. Write or call for specific data—or request Bulletin 557 describing Blood Brothers Universal Joints.



UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

ROCKWELL-STANDARD CORPORATION

ROCKWELL R STANDARD

BB UNIVERSAL JOINTS

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

THERE'S A COPY FOR EVERY TOOL ENGINEER IN AMERICA

The story of Pioneer 921-T *Direct Chilled* Aluminum Tooling Plate is too big, too new, too full of interesting data, figures and illustrated applications to be told on this single page. Tool and design engineers may have the entire story by mailing the coupon below for a copy of the new 921-T brochure. Just tell us who and where you are, and we will send you the book by return mail without cost or obligation.

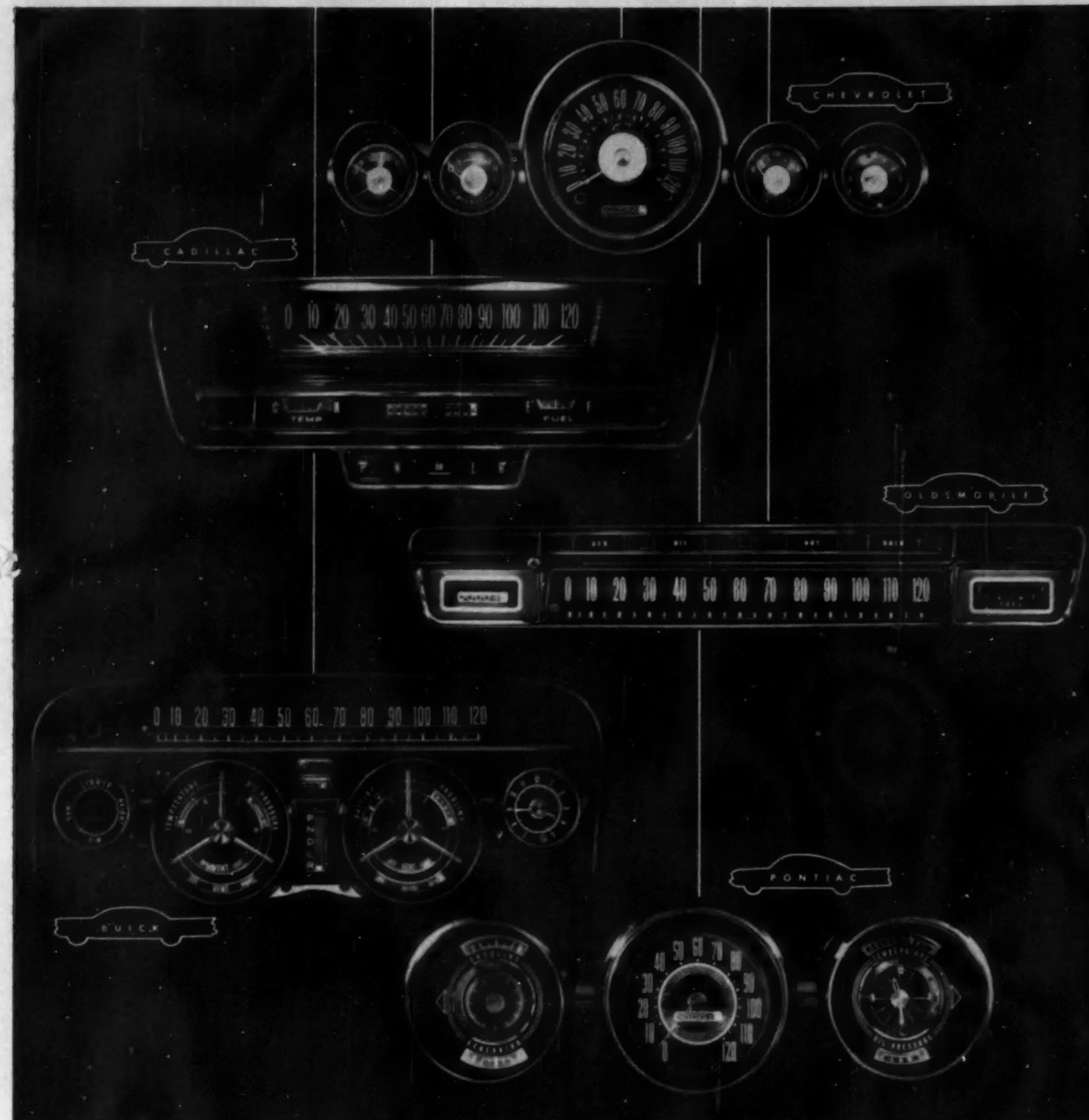
PIONEER
ALUMINUM INC.
Subsidiary of MORRIS P. KIRK & SON, INC.
Pacific Coast Unit of NATIONAL LEAD CO.
5251 WEST IMPERIAL HIGHWAY — ORegon 8-7621
Los Angeles 45, California

SNIP, TEAR OR CHOP OUT THIS COUPON AND MAIL

PIONEER ALUMINUM INC. SAE 11-8
5251 WEST IMPERIAL HIGHWAY, LOS ANGELES 45, CALIFORNIA
Send me the full story of Pioneer 921-T DC by return mail.
NAME ____________________
FIRM ____________ DEPT ________
ADDRESS ____________________
CITY ____________ STATE ________

+ INDEX TO ADVERTISERS +

Instrumental *in Beauty*



AC, long recognized as a volume producer of automotive components, also makes significant contributions toward car beauty. The glamorous 1959 instrumentation assemblies, shown above, illustrate AC's success in blending utility and beauty, function and style. Creativity of the kind so well demonstrated in this new instrument paneling is only one area where AC cooperation is yours for the asking. AC is far advanced in new electronic control concepts, for instance, and solicits your inquiry. Write or phone any of the AC offices:

Watch Walt Disney Studios' ZORRO every week on ABC-TV

AC SPARK PLUG THE ELECTRONICS DIVISION OF GENERAL MOTORS

AC

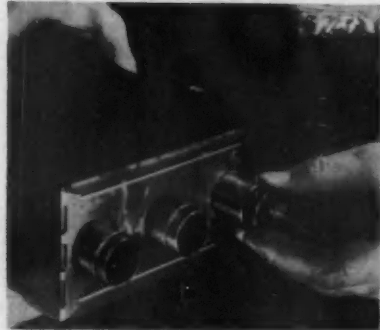
QUALITY PRODUCTS

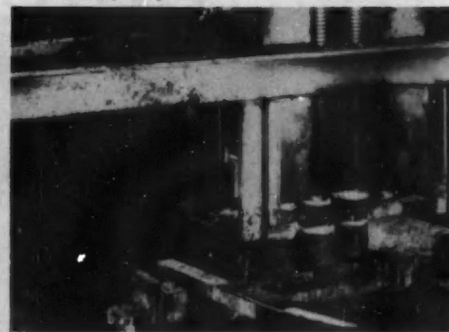
Flint—1300 North Dort Highway—CEdar 4-5611
Chicago—7074 N. Western Ave.—Rogers Park 4-9600
Detroit—General Motors Building—TRinity 5-2630

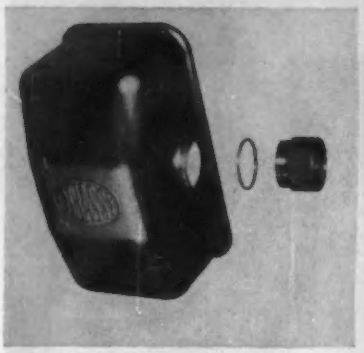
1 EASY-FLO preform ring is slid over header tubes.

2 Operator fluxes bank of assemblies prior to heating.

3 Assembly is heated by gas-air burners; heating time: 50 seconds. Note capillary action of alloy; thorough penetration makes strong, leakproof joint.







4 Components of header box; ring is preplaced.

5 Header box under heat; time: 46 seconds.

6 Brazed unit. Note neat, clean fillet around base of tube fitting.

Embassy Steel Products **Cut Unit Labor Cost 50 Per Cent** with **Handy & Harman Silver Brazing**

START WITH BULLETIN 20

It tells you why and how high speed, strength and economy are inherent in silver alloy brazing. Gives information on joint design and brazing methods. A copy is yours for the asking.

Before Handy & Harman Silver Alloy Brazing came into Embassy Steel Products' production picture, these convector radiators were welded. Now, they are brazed with EASY-FLO 35 *using gas-air heat, and unit labor cost has been cut by 50 per cent. This includes cleaning, fluxing and assembling. Not bad, eh?*

Components involved in this big saving are cold-rolled steel header plates that are brazed to fin tubes and cold-rolled steel header boxes that are brazed to steel fittings. Both of these convector assemblies are used in residential heating units.

Preformed EASY-FLO .047 wire (.015 ID) is used for brazing the header plate and fins. Photographs describe the joining steps. Each assembly goes through a 50-second heating cycle.

The header box is made in three sizes—depending on the size of the coil assembly it fits. Average heating time for any size is 46 seconds. Two sizes of EASY-FLO are used: .047 and .062 wire. Switching from one size to another involves no change in assembly or heating setup. Add this to brazing's long list of production benefits and *subtract* it from production costs.

If all we had to talk about in this case was the reduction in production time because of brazing, we'd still have a strong story to tell. You'll notice that we've said nothing about joint strength, alloy cost, corrosion resistance, ductility and so on. We can, and if you'd like to know how these benefits can apply to what you're joining right now, all you have to do is ask us. We'll be happy to tell you.

Your No. 1 SOURCE OF SUPPLY AND AUTHORITY ON BRAZING ALLOYS

HANDY & HARMAN
General Offices:
82 Fulton Street, New York 38, N. Y.
Distributors in Principal Cities